

TECHNOLOGY UTILIZATION

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ELECTRONIC TEST INSTRUMENTATION
AND TECHNIQUES

A COMPILATION



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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TECHNOLOGY UTILIZATION OFFICE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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Foreword

The National Aeronautics and Space Administration and Atomic Energy Commission have established a Technology Utilization Program for the dissemination of information on technological developments which have potential utility outside the aerospace and nuclear communities. By encouraging multiple application of the results of their research and development, NASA and AEC earn for the public an increased return on the investment in aerospace research and development programs.

Electronic instrumentation is an essential element in every aspect of NASA's aerospace programs. Launch vehicles and spacecraft are controlled, stabilized, guided, and tracked electronically. Scientific information is gathered, processed, and transmitted back to Earth by electronic instrumentation. On Earth, the information is received, analyzed, and recorded—again electronically. Electronic devices constitute the brain, nerves, and senses of flight vehicles. Without electronic instrumentation, present achievements in aerospace exploration would not have been possible.

The successful operation of the instrumentation in the harsh environment of outer space has required the development of sophisticated electronic test equipment and techniques; in many of the electronic test programs the instrumentation is just as complex as the system which is undergoing test—test procedures to check out a flight computer often requires a test computer with equal or greater capabilities. This compilation deals with the broad and diverse technology of electronic test instrumentation and techniques that have been developed as NASA has progressed in fulfilling its role of exploring the aerospace environment. The material has been selected and divided into categories which represent—not the original intent of the instrumentation—but the transfer of the test capability to commercial and industrial applications.

The six major divisions include: electronic test instrumentation that generally can be constructed by the skillful hobbyist or electronics technician; instrumentation test procedures for measuring the properties of simple devices and systems; instrumentation that can be applied in the expanding field of electronics test instrumentation in medical applications; instrumentation that can be used in solving the chronic problems which confront us in controlling and defining the pollution of the earth's ecological system; sophisticated and complex electronics for the test of large systems, such as digital computers and communications networks; and finally, the most important function of test instrumentation—to assure the quality and reliability of electronic components and systems.

Additional technical information on individual devices and techniques can be requested by circling the appropriate number on the Reader's Service Card included in this compilation.

Unless otherwise stated, NASA and AEC contemplate no patent action on the technology described.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this compilation.

RONALD J. PHILIPS, *Director*
Technology Utilization Office
National Aeronautics and Space Administration

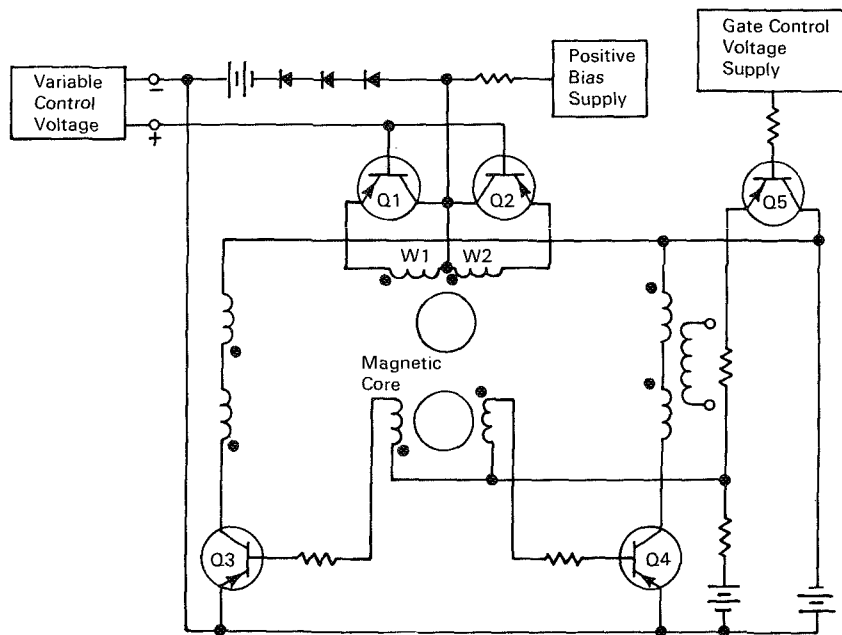
Contents

	Page
SECTION 1. Simple and Inexpensive Laboratory Test Instrumentation	
Variable-Frequency Magnetic Multivibrator Generates Stable Squarewave Output	1
Dual-Voltage Power Supply Has High Efficiency	1
Electronic Ohmmeter Provides Direct Digital Output	2
Ultra-Sensitive Electrometer Generates Digital Output	3
Electronic Test Instrument Generates Extremely Small Current Signals	4
Inexpensive Square-Wave Generator	4
Frequency Standard for Precision Calibration	5
A Power Triangular Wave Generator	6
SECTION 2. Methods for Testing Electronic Components and Circuits	
Semiconductor Devices Can Be Tested Without Removal from Circuit	7
Novel Probe Simplifies Electronic Component Testing	8
Piezoresistive Gage Tests Pin-Connector Sockets	8
Simple Test Setup Provides Resonant Frequency Measurements of Ferrite Devices	9
Electronic Test Procedure Permits Evaluation of Solenoid Valves	9
Electrical Continuity Scanner Identifies Connector Wires	10
Phase Detector Ensures Proper Phasing in Power Circuits	11
Low Value Resistors and Shunts Can Be Calibrated with Modified Double Bridge Instrument	12
SECTION 3. Test Instrumentation for Biomedical Applications	
Improved Perceptual-Motor Performance Measurement System	12
Digital Output Cardiometer Measures Rapid Changes in Heartbeat Rate	13
Electronic Test Instrument Simulates Phonocardiogram of Human Heart	14
Electronic Test Simulator Generates Physiological Waveforms	14
Electronic Dummy for Acoustical Testing	15
Electronic Sensor Measures Skin Temperature	16
DC Instrument Measures Physiological Electrical Potentials	17
SECTION 4. Electronic Test and Measurement Equipment for Earth Resources Applications	
Sensitive Bridge Circuit Measures Conductance of Electrolyte Solutions	18
Instrumentation for Potentiostatic Corrosion Studies With Distilled Water	19

Conditioning of Pulses from Aerosol-Particle Detectors	19
Portable Instrument Monitors Transducer Performance	20
SECTION 5. Electronic Instrumentation for Test and Checkout of Complex Systems	
Electronic Test Device Senses Malfunctions in Test Instrumentation	21
Solid State Annunciator Displays Malfunctions in Complex Electronic Systems	22
Electronic Test and Checkout System Monitors Discrete Computer Inputs	23
Test Monitor Assures Availability and Quality of Communication Channels	24
Numerical Data Frame Readout System Used in Testing Telemetry Systems	25
Test Instrumentation Records Current-Voltage Characteristics of Thermionic Energy Converters	26
Facility Power Monitoring System Records Transient Disturbances	26
SECTION 6. Electronic Test Methods Ensure Quality Control and Reliability Assurance	
Quick and Reliable Technique for Evaluating Physical Stresses on Electronic Components	27
Internal Resistant Measurement of Battery Separator Materials Aids in Quality Assurance	28
Universal Mounting Board for Quality Assurance Tests of Electronic Components	29
Method of Detecting Loose Particles in Sealed Relays Increases Reliability	30
Technique for Calculating the Armature Motion of a Hermetically Sealed Relay	30
Tester Checks Operational Performance of Circuit Breakers	31

Section 1. Simple and Inexpensive Laboratory Test Instrumentation

VARIABLE-FREQUENCY MAGNETIC MULTIVIBRATOR GENERATES STABLE SQUAREWAVE OUTPUT



A variable frequency magnetic multivibrator provides a stable squarewave output over wide variations in temperature and power supply voltage. A novel feature of the multivibrator is a frequency control circuit which operates in a full wave mode rather than only over a portion of the multivibrator cycle. Greater operational stability is achieved at the low operating frequencies, and undesirable high frequency modes are rejected.

The frequency of the multivibrator is controlled by a circuit (see fig.) which consists of a full wave voltage limiter, Q1 and Q2, and transformer wind-

ings W1 and W2. The operation of the voltage limiter is controlled by the level of the variable control voltage. An electronic gate starts and stops the multivibrator.

The square wave generator can be used in such applications as the control of synchronous motors, in laboratory test instruments, and as a clock in digital logic circuits.

Source: Steven Paull
Goddard Space Flight Center
(GSC-AE-21)

Circle 1 on Reader's Service Card.

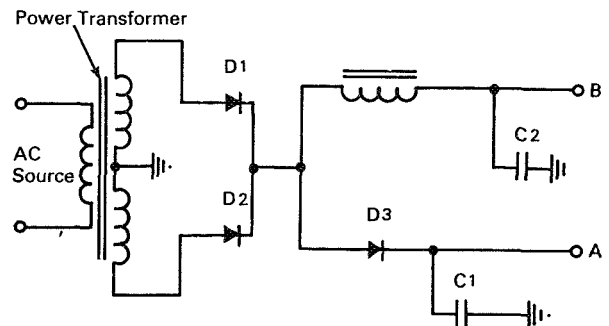
DUAL-VOLTAGE POWER SUPPLY HAS HIGH EFFICIENCY

Bipolar transistor circuits generally require several different dc supply voltages. Conventional power supplies require a tapped transformer with

a separate rectifier and filter for each output voltage, or load dividing resistors which dissipate power and decrease the regulation capability. The

simplified power supply (see fig.) employs a single rectifier circuit connected to two passive branches from which separate dc output voltages can be taken.

The primary winding of the power transformer is connected to the source, and the secondary winding is connected to the rectifier, consisting of diodes D1 and D2. The unfiltered output is fed, in parallel, to a conventional choke-input filter branch and a diode-capacitor branch. The diode, D3, in this branch conducts on the peaks of the rectifier current and charges capacitor C1 to the peak voltage across one-half of the secondary winding of the power transformer. The voltage at terminal A is approximately 40% greater than at terminal B. The required peak inverse-voltage rating of diode D3 is only one-half the peak voltage across the full sec-

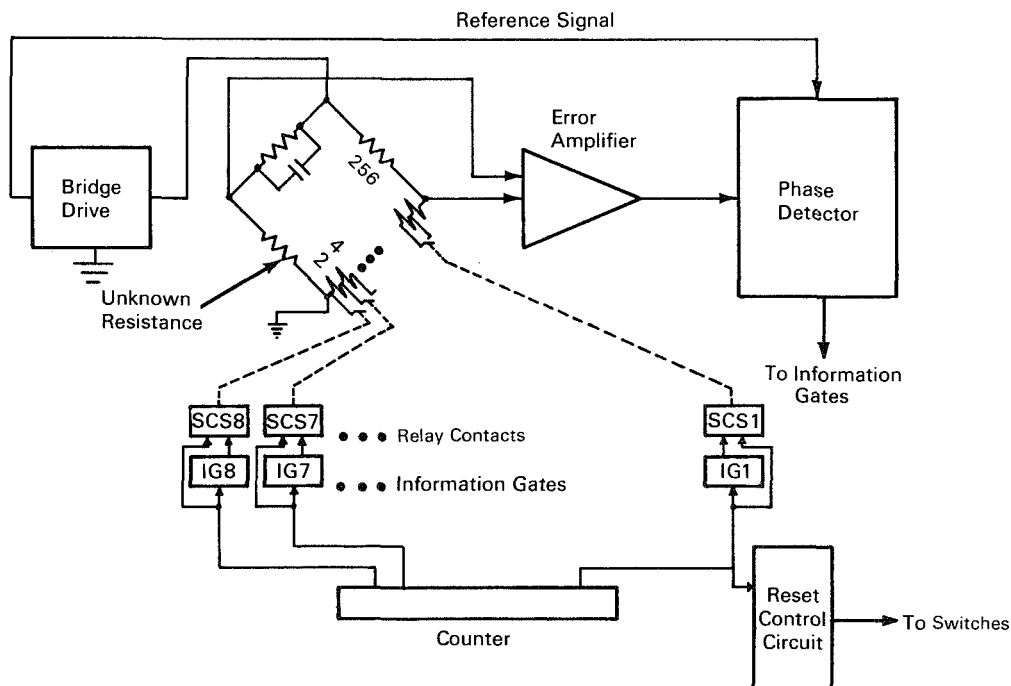


ondary winding of the power transformer. The ratio of the output voltages may be varied by proper choice of component values.

Source: Lewis Research Center
(LEW-90107)

Circle 2 on Reader's Service Card.

ELECTRONIC OHMMETER PROVIDES DIRECT DIGITAL OUTPUT



An electronic ohmmeter, containing a self-balancing Wheatstone bridge circuit, reads out the value of resistive devices in digital form.

Each binary-valued resistor (2, 4, 256 ohms) in the adjustable leg of the bridge is paralleled with a reed-relay which shorts out the resistor

when energized. Initially, all of the contacts are open so that the adjustable resistance assumes the maximum value. The application of a square-wave signal from the driver oscillator causes an error signal to be generated when the bridge is unbalanced. The error signal is amplified and then com-

pared in the phase-detector with the bridge-drive reference signal. The combination of the error signal from the phase detector and the output from the counter circuit energizes the relay with the largest binary resistor. Depending on the magnitude of the error signal remaining, the resistor will either remain in the circuit or the relay contact will open and remove it. This type of resistance sampling is sequentially repeated for the remaining resistors until the error signal is reduced to a minimum. An output from each relay is used for the

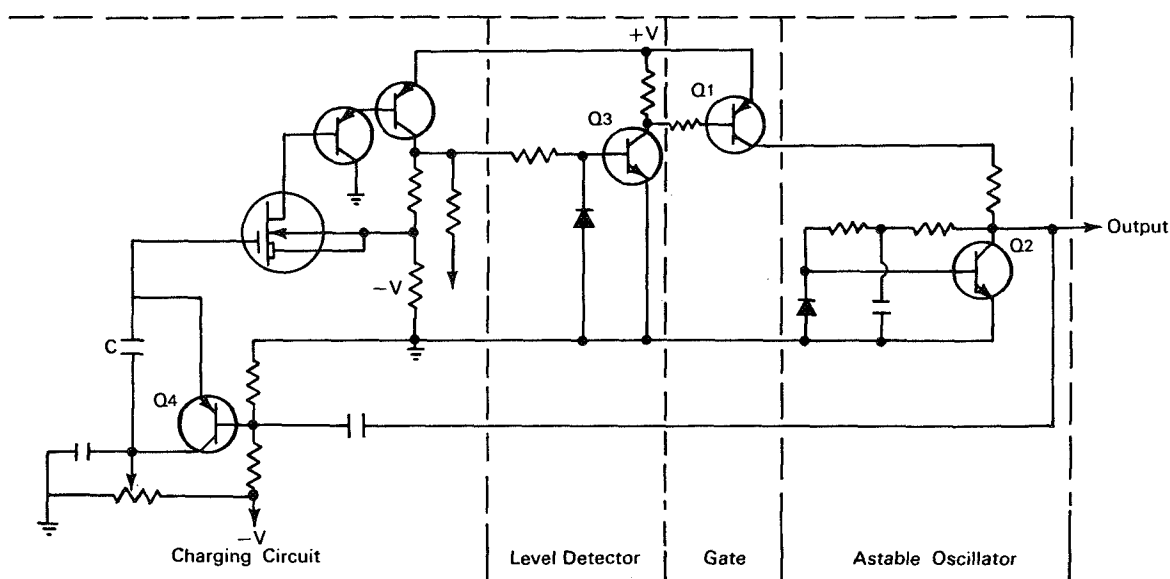
binary readout of the unknown resistance. Higher orders of accuracy can be derived from the bridge circuit by increasing the number of bits or altering the bridge ratio.

Simplicity of the circuit and the convenience of the digital readout make the instrument ideal for production line testing of resistors.

Source: John Semyan
Goddard Space Flight Center
(GSC-90363)

Circle 3 on Reader's Service Card.

ULTRA-SENSITIVE ELECTROMETER GENERATES DIGITAL OUTPUT



A four-stage, transistorized electrometer measures currents from 10^{-6} to 10^{-12} amperes and produces a digital output proportional to the signal input. The instrument can be used to monitor outputs from photodetectors, ionization gages, and similar devices which generate small current signals.

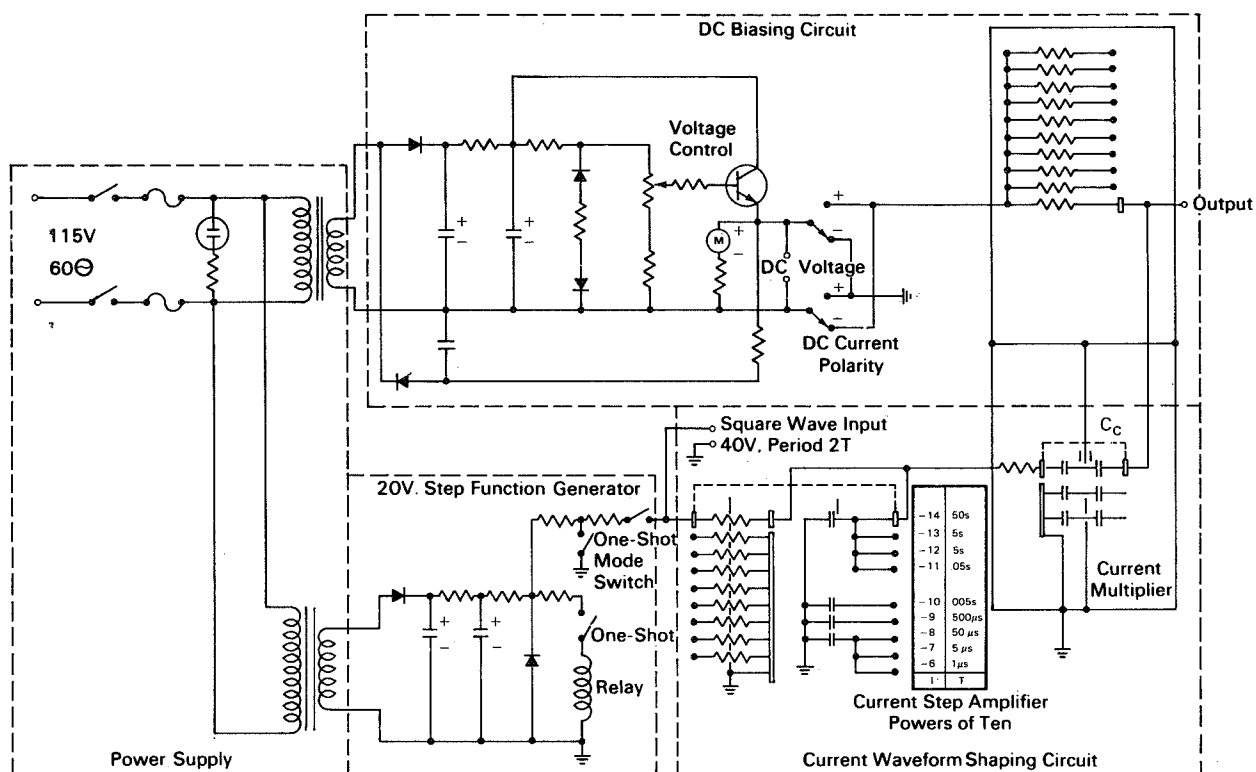
Initially, the gate transistor Q1 is not conducting and prevents the positive supply from being applied to the astable oscillator Q2. When an input current is applied to the circuit, capacitor C begins to charge and at a predetermined level, triggers the level detector Q3. The level detector turns the gate on and applies a voltage to oscillator Q2 which generates an output pulse. The trailing edge of this pulse is fed back to Q4 which turns on and dis-

charges C, returning it to zero charge level. The level detector Q3 is no longer energized and the gate is turned off. The process is repeated to produce a series of pulses from the oscillator. Because the time required for C to charge depends on the magnitude of the input current, the frequency of the output pulses from Q2 is a direct indication of input current magnitude. An important feature of the electrometer is the elimination of a logarithmic compression network which is usually required in large dynamic range instruments.

Source: Henry Doong
Goddard Space Flight Center
(GSC-90288)

Circle 4 on Reader's Service Card.

ELECTRONIC TEST INSTRUMENT GENERATES EXTREMELY SMALL CURRENT SIGNALS



The signal generator provides a series of square-wave current outputs in the range of 10^{-4} to 10^{-12} amperes. The waveforms, which have negligible overshoot (ringing), are generated with rise times in the range from 0.1 to $100\mu\text{sec}$.

Originally designed to test video preamplifiers in a scanning electron microscope system, the test instrument can be used to provide calibrated current test signals for low-signal level amplifiers, ionization gages, pulse height analyzers, and sensitive electrometers.

In operation, a square-wave input voltage to the RC T-network produces a triangular shaped voltage input to C_c where it is converted to a square-wave current output. Different values of the RC network are selected to produce the desired wave-shape properties of the output signal.

Source: W. K. Brookshier
Argonne National Laboratory
(ARG-90276)

Circle 5 on Reader's Service Card.

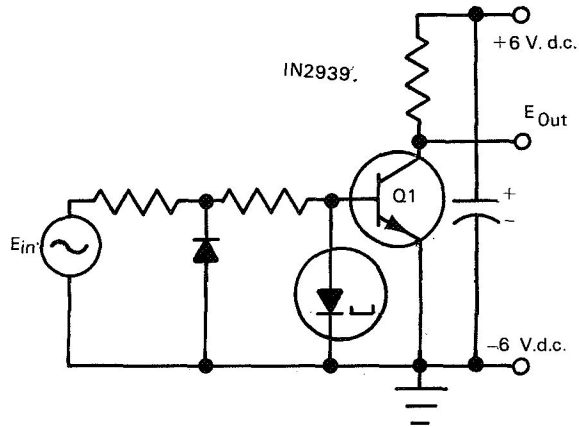
INEXPENSIVE SQUARE-WAVE GENERATOR

An instrument that converts the sinusoidal output of a wide range oscillator to a square wave of 5 volts peak-to-peak amplitude has been fabricated from inexpensive, off-the-shelf components. The reliable square-wave generator can be used in basic electronics research or malfunction analysis. The instrument may also be incorporated as a

basic building block in other types of electronic circuits.

The electronic unit is basically a switch or driver circuit that performs a shaping and clipping operation to the sinusoidal input. During the positive portion of the input signal, the transistor (Q1) remains off until the peak current point of the tunnel

diode is exceeded. When this occurs, the tunnel diode rapidly switches from a low voltage to a high voltage peak, thus diverting the input drive

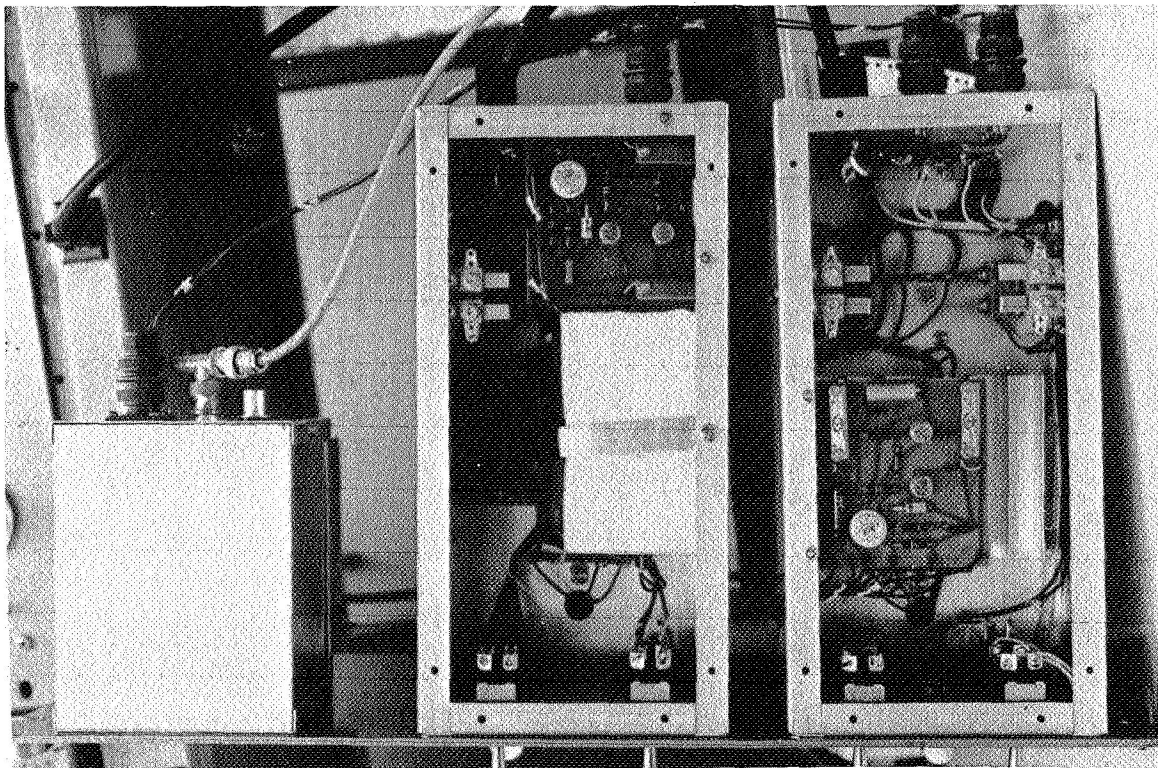


current to Q1. During the negative half cycle, the tunnel diode and Q1 are reversed biased. The application of a 1N2939 tunnel diode increases the rise and fall time of the square-wave output to less than one microsecond. The repetition rate of the square waves is controlled by the frequency range of the oscillator and the amplitude of the supply voltage and output loading. If desired, a clamp circuit may be added to achieve constant output amplitude, regardless of load variations.

Source: E. M. Turnbow and T. C. Marshall of North American Rockwell Corp. under contract to Manned Spacecraft Center (MSC-11939)

Circle 6 on Reader's Service Card.

FREQUENCY STANDARD FOR PRECISION CALIBRATION



A highly stable one-MHz, battery or line operated, frequency standard shown in the figure can be used to calibrate precision frequency counters and oscillators. The unit has a low current drain mak-

ing it adaptable to portable operation for on-site operations.

The frequency standard consists of a one-MHz crystal oscillator, two power supplies and a 10:1

frequency divider. Automatic power change-over is provided in case of power failure, and panel lights indicate if the unit is on standby operation and if there has been a power failure. A comparator is used to monitor the frequency and makes periodic adjustments.

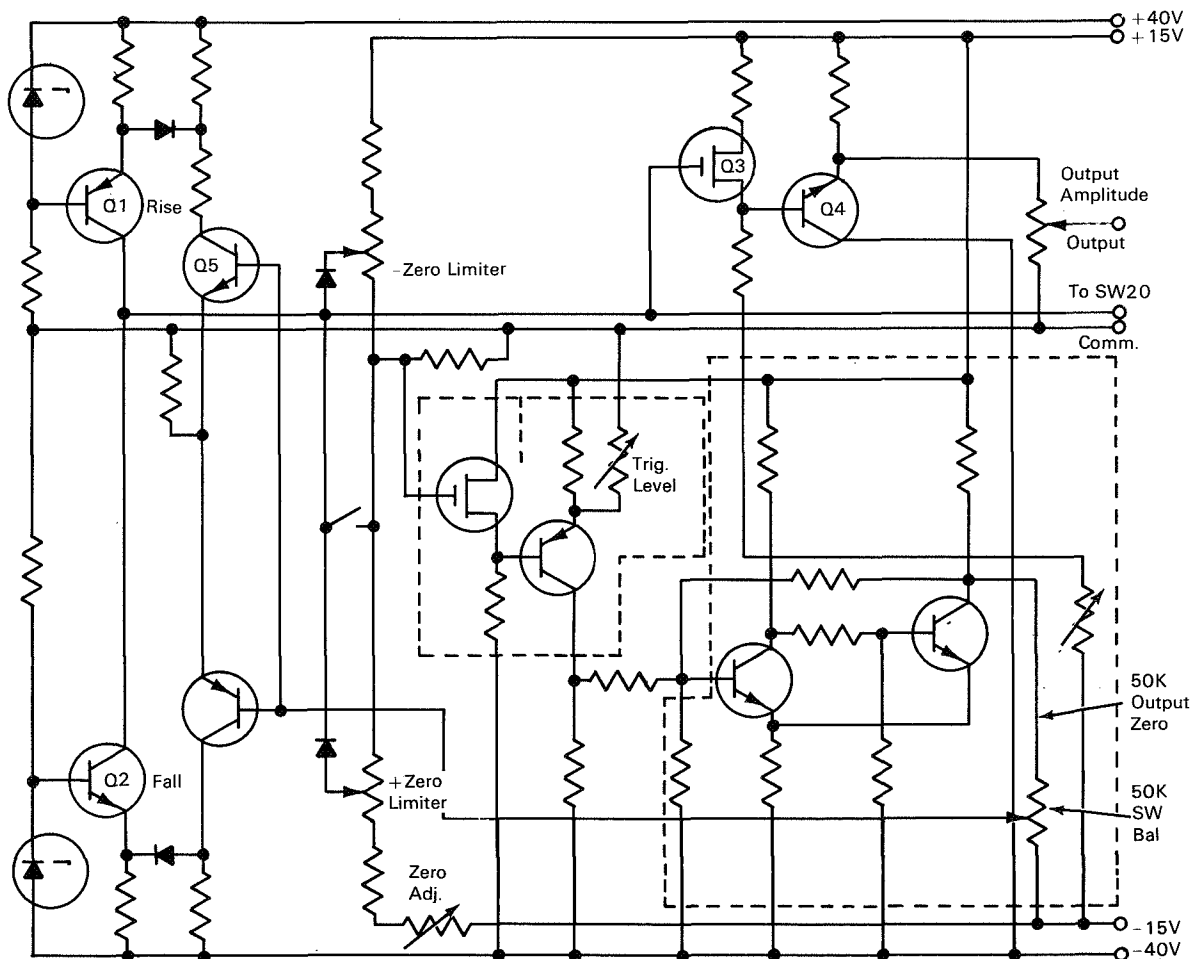
This frequency standard can be fabricated at a cost savings of approximately \$2500 over a

comparable commercial unit which would provide a stability of less than 3×10^{-10} per day.

Source: Richard D. Naron of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-14281)

Circle 7 on Reader's Service Card.

A POWER TRIANGULAR WAVE GENERATOR



The power triangular wave generator shown in the schematic figure has general application in electronic instrumentation where a linearly varying driver voltage is required. The instrument, originally designed to test magnetic films, can be used to test electromagnets such as those used in commercial TV receivers.

In operation, dual switch gated current generators, with both positive and negative amplitudes, are used to generate the triangular output waveforms. An important feature of this generator is the capability of varying each waveform output independently. Other advantages of the power triangular generator include: (1) the rise and fall

slopes of the outputs are equal in amplitude and slope; (2) the rate of rise or fall is independently adjustable; (3) the charging wave operates independently of the discharging wave; (4) the sawtooth wave generators of opposite slope operate independently; (5) termination of rise slope is the initiating point for start of fall slope and vice versa; and (6) frequency is a function of amplitude limit device setting.

The generator can have application in govern-

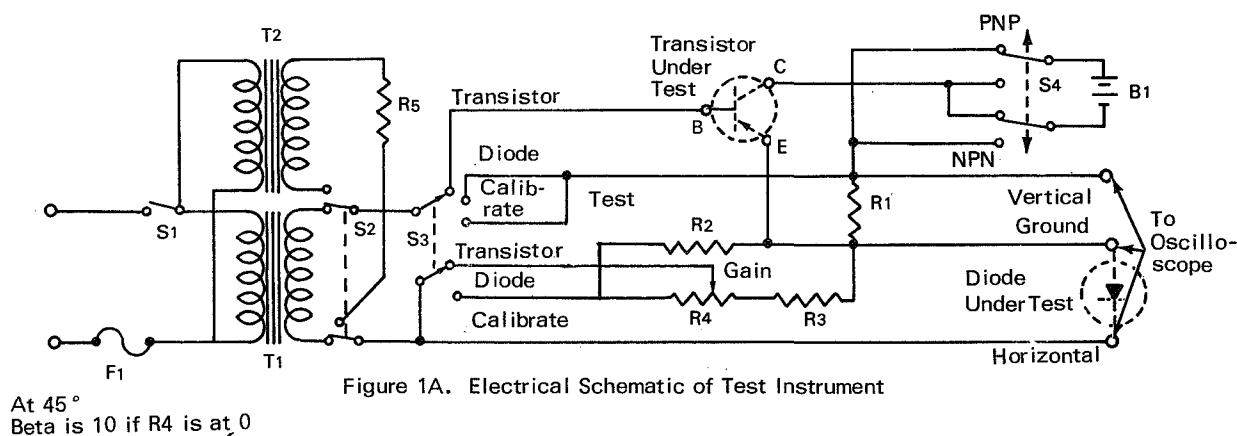
ment, school, university or research laboratories wherever a triangular wave current is needed for test purposes at relatively high power.

Source: John E. Guisinger of
Caltech/JPL
under contract to
NASA Pasadena Office
(NPO-10656)

Circle 8 on Reader's Service Card.

Section 2. Methods for Testing Electronic Components and Circuits

SEMICONDUCTOR DEVICES CAN BE TESTED WITHOUT REMOVAL FROM CIRCUIT



At 45°
Beta is 10 if R4 is at 0

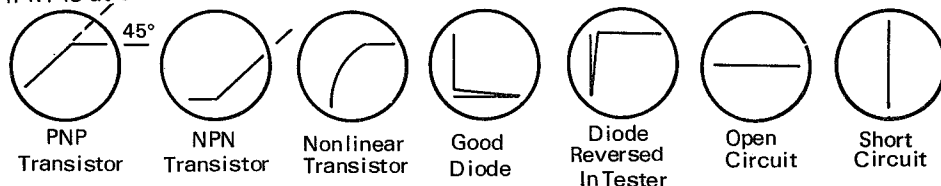


Figure 1B. Typical Waveforms of Devices Undergoing Test

The circuit of the test instrument shown in Figure 1A can be used for a quick check of semiconductor devices (properties) while they are soldered in place. The operating characteristics are obtained by the application of ac voltages from T1 and T2 and the dc collector bias voltages from B1. With proper adjustment and calibration of the test circuit parameters, approximate values of current gain (Beta) and backward and forward resistances can be obtained. Typical waveforms taken from

the oscilloscope are shown in Figure 1B. A nominal degree of familiarity with the ideal waveforms is required for the proper interpretation of the waveforms of the devices undergoing tests.

Source: Burdelle C. Allen of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-1163)

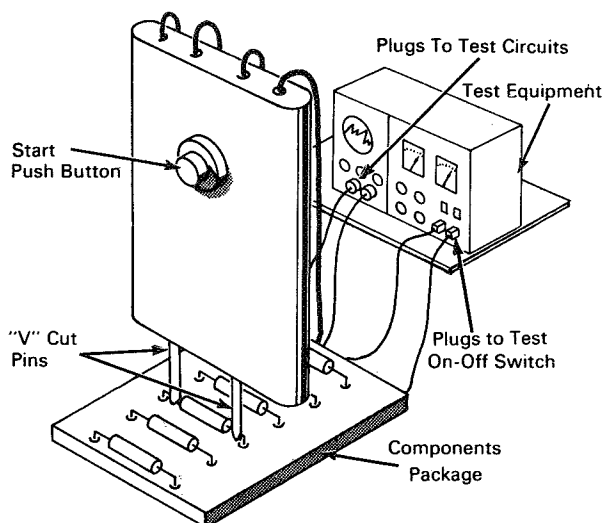
No further documentation is available.

NOVEL PROBE SIMPLIFIES ELECTRONIC COMPONENT TESTING

A test probe used in conjunction with standard equipment enables the test of axial-lead components in their original packages. The handling of small, sensitive components which could result in damage to leads and seals is eliminated. The electronic components need not be unpackaged and repackaged.

The test probe consists of a plastic case that contains the test pins, the leads, and the control switches. The metal test pins have v-shaped slots filed in their ends to receive the two axial leads of the component. The test probe is pushed against the two leads of the component (still in the original package) and the operator depresses the start button to begin the testing sequence. When the test sequence is completed, the operator moves the probe to the next component in the package and repeats the operation.

The test probe could readily be modified to test any type of electronic component which has axial leads. With this device, a shipment of 17,000 diodes was tested, catalogued, and stored in six days. Experience shows that at least three additional



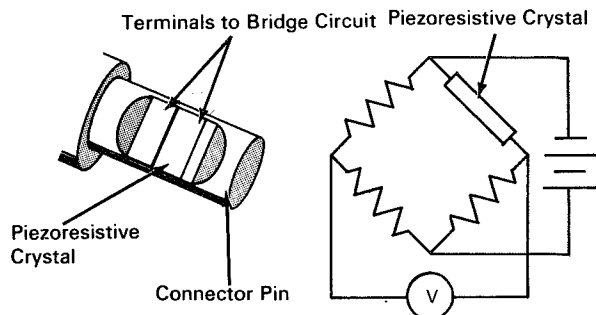
weeks would have been needed using a previous method of unpackaging, testing, and repackaging.

Source: Warren F. Synder
Goddard Space Flight Center
(GSC-90342)

Circle 9 on Reader's Service Card.

PIEZORESISTIVE GAGE TESTS PIN-CONNECTOR SOCKETS

An inspection method using a test pin the same size as a connector pin measures the electrical contact characteristics of pin-connector sockets that employ retainer springs. The spring must exert sufficient force to ensure proper electrical contact between the socket and pin.



A piezoresistive silicon crystal is rigidly mounted in a recess on the test pin and connected as one leg

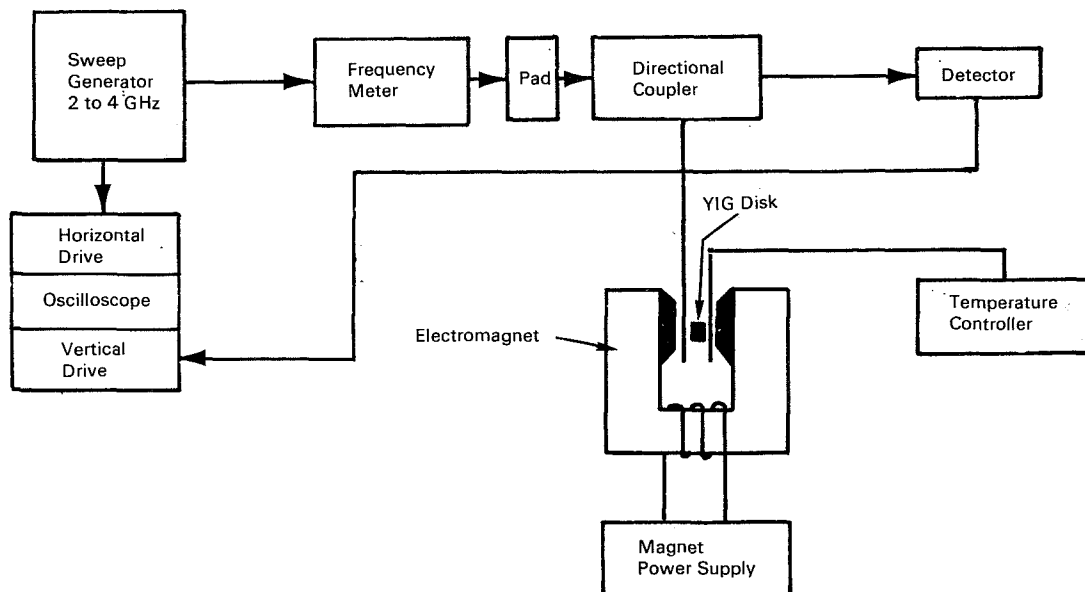
of a bridge circuit. When the pin is inserted into a socket to be tested, the force exerted by the retainer spring causes the pin and crystal to deflect slightly. The change in the resistance of the crystal due to the deflection is directly proportional to the force exerted by the retainer spring. A voltmeter in the bridge circuit is calibrated to give a direct reading of this force. For inspection testing, a lower tolerance limit is marked on the voltmeter face to indicate acceptance or rejection of the sockets.

This testing method can be applied to a multiple-connector socket by using a connector with multiple test pins. The outputs of the pins would be fed into a programmed sequencing switch for automatic acceptance or rejection of the socket.

Source: William W. Bond
NASA Pasadena Office
(XNP-3918)

Circle 10 on Reader's Service Card.

SIMPLE TEST SETUP PROVIDES RESONANT FREQUENCY MEASUREMENTS OF FERRITE DEVICES



The resonant frequency of a resonance isolator in a maser is determined by the shape and thickness of the isolator material, usually an yttrium iron garnet (YIG) disk, and the applied magnetic field. A simple tester has been designed and fabricated which enables the direct measurement of the resonant frequency of the YIG disk while it is mounted on an isolator strip. The tester includes a combination of clamp, temperature-controlled electromagnet, and a coupling line element for holding and coupling the signal to the disk under test; the coupling line also receives the reflected signal.

The signal from a microwave frequency generator is applied to a directional coupler through a frequency meter and resistive pad. The frequency-determining sweep-voltage is applied to the horizontal axis of the oscilloscope; the vertical axis of the oscilloscope receives the detector output voltage which is the reflected microwave power received

by the directional coupler from the line. The oscilloscope presentation appears as a straight horizontal line except for a sharp dip which occurs at the resonant frequency of the ferrite; the minimal response point is measured with the frequency meter. The directional coupler transfers the microwave signal from the generator to the line and directs the reflected signal from the line to the detector. The magnet is adjusted electrically to provide the desired field strength; this presents an environment similar to that which the YIG ferrite element encounters in a maser. The magnet, directional coupler, strip lines, and YIG disk are maintained at a constant temperature by a thermal control unit.

Source: Robert C. Clauss of Caltech/JPL under contract to NASA Pasadena Office (NPO-10678)

Circle 11 on Reader's Service Card.

ELECTRONIC TEST PROCEDURE PERMITS EVALUATION OF SOLENOID VALVES

The operating characteristics of solenoid valves can be determined from the current and voltage waveforms of the solenoid coil as the valve opens and closes. Analysis of the waveforms with respect

to time and the particular phase of the valve cycle accurately describes the performance of the valve.

The recorded current trace (Fig. 1) of the energized solenoid coil increases linearly to a maximum

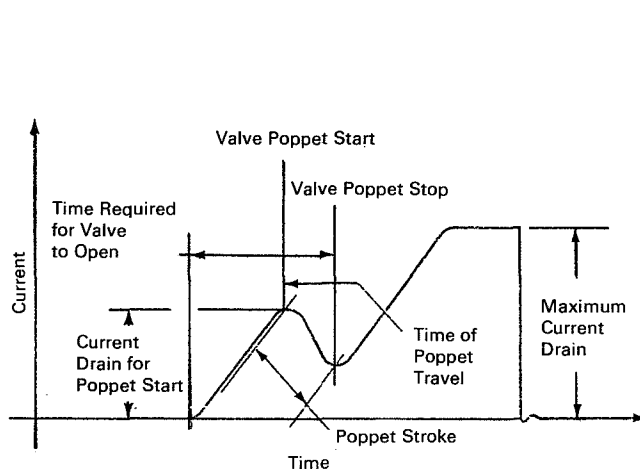


Figure 1. Current Trace

current level; when the valve is energized, the motion of the poppet (slug) produces an induced back voltage that reduces the current flow. When the poppet stops at the completion of the opening cycle, the current continues to increase linearly and finally reaches a maximum holding level. Pictorially, the waveform shows a hill and valley interrupting the otherwise linear current function. The apex of the hill indicates the start of poppet motion and the base of the valley indicates the end. A voltage waveform (Fig. 2) is required to provide a record of the valve closure cycle. The analysis of this waveform is similar to the current waveform.

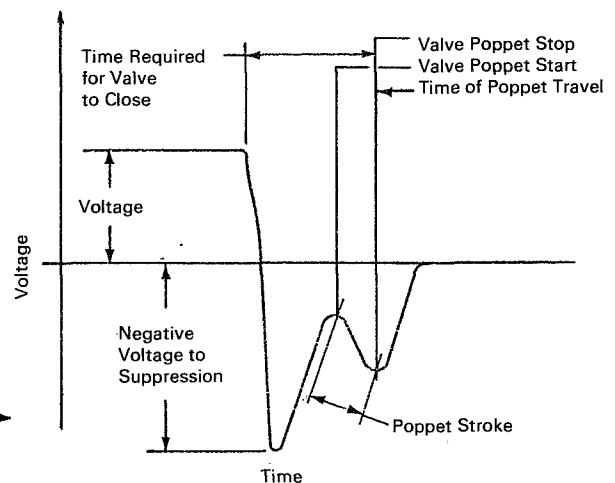


Figure 2. Voltage Trace

Although the use of current and voltage waveforms in determining solenoid valve properties is not new, the electronic instrumentation can be extended to provide a very accurate means of monitoring operations of a complete industrial control system.

Source: S. Blackburn and J. T. Abe of
McDonnell Douglas Corp.
under contract to
Marshall Space Flight Center
(MFS-12458)

Circle 12 on Reader's Service Card.

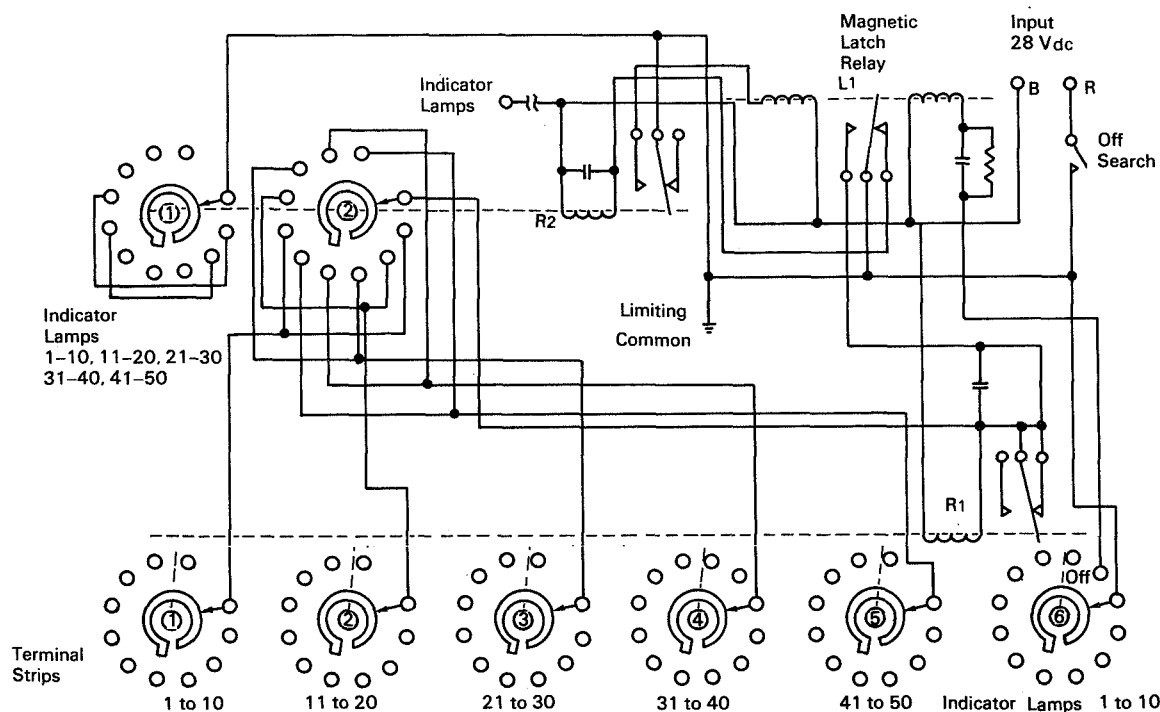
ELECTRICAL CONTINUITY SCANNER IDENTIFIES CONNECTOR WIRES

The electrical continuity scanner shown in the schematic is ideal for production line testing of pre-fabricated cables for large complex electrical systems. In the test line operation one known point is electrically connected to the common post of the electrical continuity scanner with a temporary jumper wire. Actuation of the switch to the search position causes the rotary relays to step or search until a circuit having electrical continuity is reached, or the search switch is released. This automatic stepping is accomplished through use of contacts provided on the automatic electric relay (R1) to make it free running when desired. After 10 wires have been scanned, a second automatic electric relay (R2) is actuated one position by a

latching relay (L2) that transfers the test set to the next 10 circuits. In this manner, 5 decks with 10 positions can be used to scan 50 circuits in a fully automatic or free running mode.

If a continuity occurs, a relay is energized to prevent further search and a lamp is lit which indicates the number of the post providing continuity. The search switch is then released and the known endpoint recorded with the post number providing continuity. The jumper wire is moved to the next known point and the search procedure is repeated until all wires in the bundle have been correlated with their respective known ends.

Modifications can be made to the basic plan to provide circuitry for scanning up to 250 wires. The

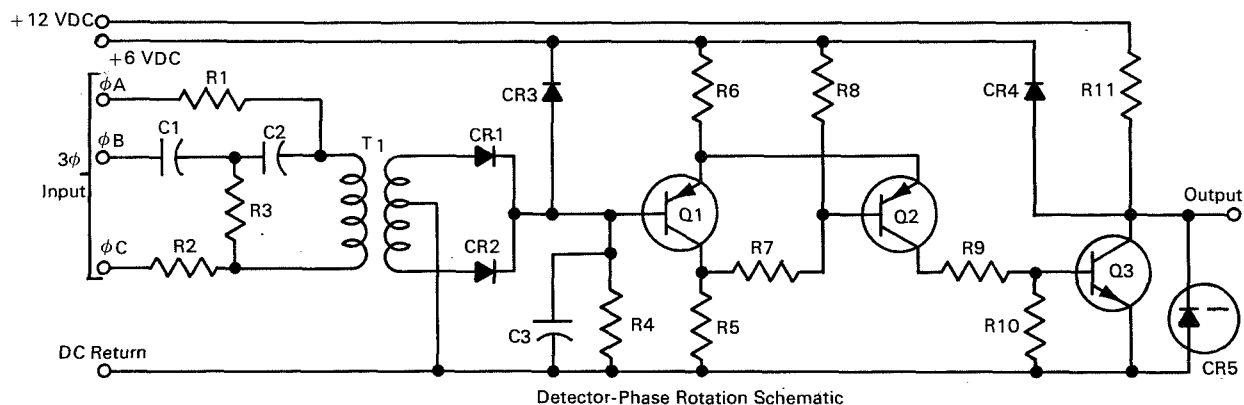


scanner can also be used for the rapid fabrication of multiwire electrical cables by minimizing termination errors prevalent with prior methods of wire identification.

Source: Ralph A. Diclemente and
Howard C. Boulton of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-90626)

Circle 13 on Reader's Service Card.

PHASE DETECTOR ENSURES PROPER PHASING IN POWER CIRCUITS



The phase rotation detector can be used to detect phase rotation in any three-phase power circuit. The detector consumes a nominal amount of

power and can be fabricated by using high density packaging methods.

During the initial application of power to an elec-

trical system, the phasing of the line voltages must be tested to eliminate potential hazardous conditions and possible equipment damage. This phase detector produces a 6 V dc or 0 V dc output indicating a phase rotation of ACB or ABC respectively of the three-phase lines (see fig.). The three-phase 400 Hz input is phase shifted and summed in the input circuitry, producing no output if rotation is ACB, and a voltage if rotation is ABC. The output from the phase shifting and summing network passes through a transformer and is rectified and

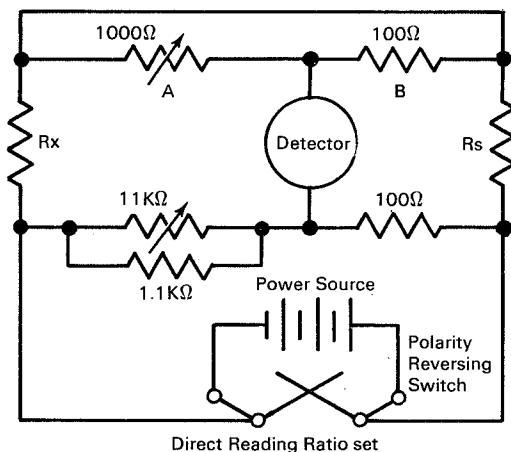
filtered. The resulting dc voltage operates a Schmitt trigger which drives the output stage. The important features of the detector are the small size, high input/output isolation (greater than 100 megohms), and high input and output impedances.

Source: C. J. Rogers and J. R. Lorchik of North American Rockwell Corp. under contract to Manned Spacecraft Center (MSC-11855)

Circle 14 on Reader's Service Card.

LOW VALUE RESISTORS AND SHUNTS CAN BE CALIBRATED WITH MODIFIED, DOUBLE BRIDGE INSTRUMENT

Four-terminal resistors can be tested and calibrated with a double bridge, one-half consisting



of a direct reading ratio set (DRRS) and the second half being constructed from regular resist-

ance decade boxes of moderate accuracy. After the bridge is balanced, the ratio between the unknown resistor and the standard is read from the DRRS dials, to the precision of the DRRS.

Using standard resistors, the exact ratio, including the leads which are to be used with the double bridge arrangements, is initially established, then balanced, and the ratio of unknown to the standard equals the ratio setting on the DRRS dials.

The simplicity and minimal cost of the instrument and the straightforward measurement procedure give this technique wide application in test and inspection laboratories.

Source: Cyril R. Miller of The Boeing Company under contract to Marshall Space Flight Center (MFS-14104)

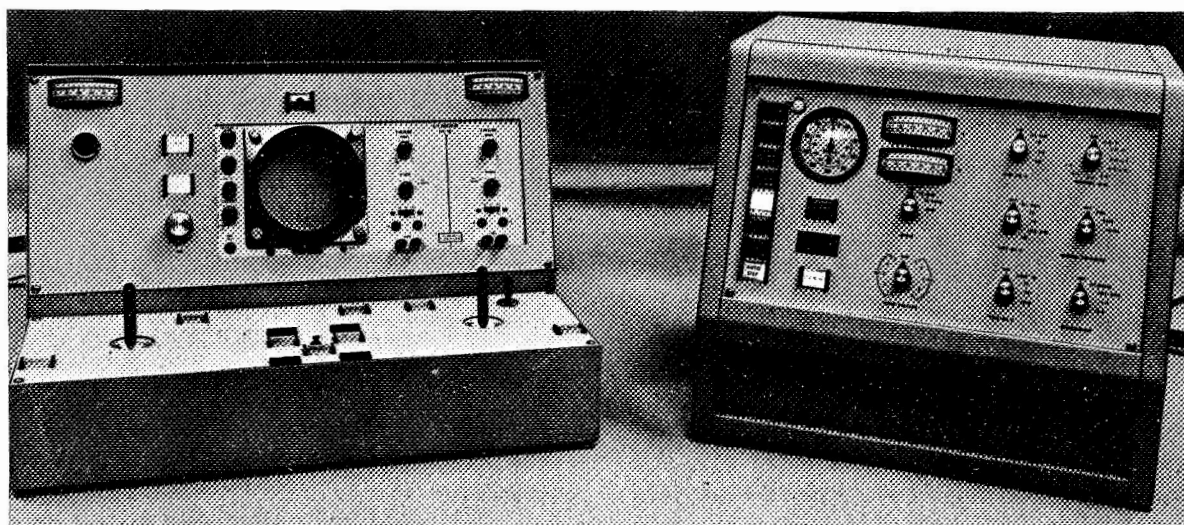
No further documentation is available.

Section 3. Test Instrumentation for Biomedical Applications

IMPROVED PERCEPTUAL-MOTOR PERFORMANCE MEASUREMENT SYSTEM

A series of biophysical tests has been developed to measure perceptual and physical performance of adult males. The electronic test instrumentation for the physical measurements (see fig.) is designed

as two units, one for the subject, containing all test display and response elements, and the other an experimenter console in which all test setups, programming, and scoring are accomplished. Eighteen



Subject Console

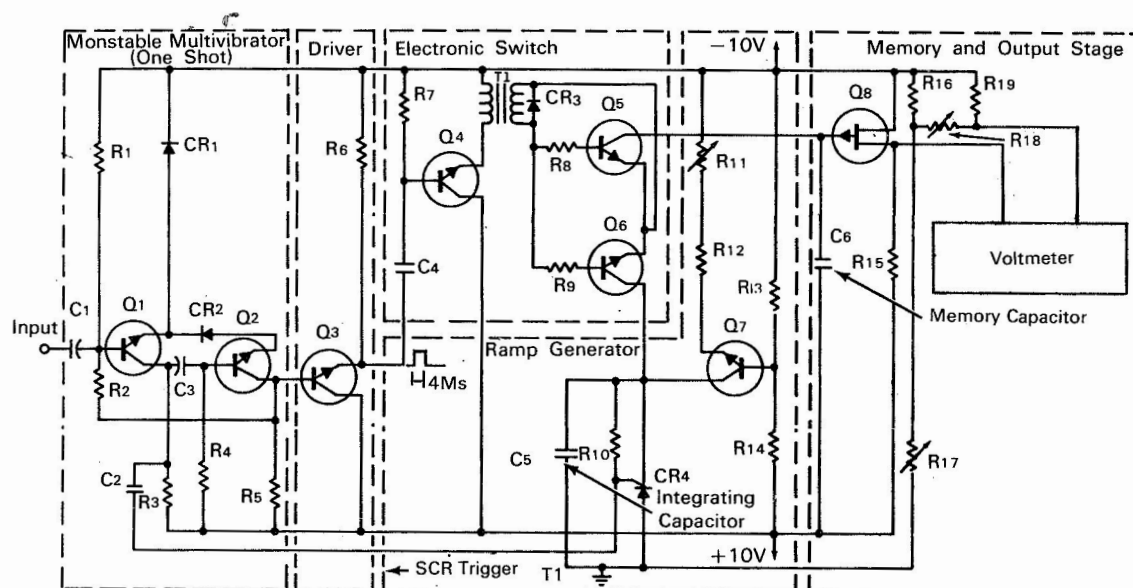
Experimenter Console

basic measurements included in the program in the form of standard tests ranged from simple paper-and-pencil tests to sophisticated electronic and electromechanical devices. The electronic test system can be used to determine the perceptual and motor skills of pilot trainees for military and commercial aircraft.

Source: R. E. Reilly and J. F. Parker, Jr. of Biotechnology Inc. under contract to NASA Headquarters (HQN-10123)

Circle 15 on Reader's Service Card.

DIGITAL OUTPUT CARDIOTACHOMETER MEASURES RAPID CHANGES IN HEARTBEAT RATE



A cardiometer has been developed to produce an output voltage proportional to the heart-

beat rate of a human on a beat-by-beat basis. Direct reading in beats per minute are obtained on

a linear scale of a digital voltmeter. Square-wave pulses, derived from a patient's electrocardiogram at a frequency proportional to the heartbeat rate, are applied to the cardiometer. After passing through a series of signal conditioning circuits, a voltage output is derived from the input pulse that represents the true heartbeat rate. The output can

be displayed and stored for future, medical analysis.

Source: Howard Vick
Manned Spacecraft Center
(MSC-90133)

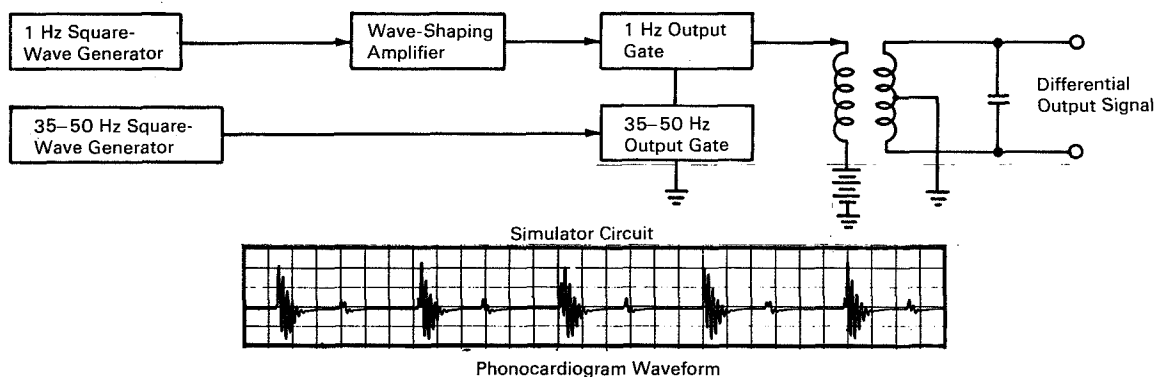
Circle 16 on Reader's Service Card.

ELECTRONIC TEST INSTRUMENT SIMULATES PHONOCARDIOGRAM OF HUMAN HEART

A phonocardiogram that produces a pattern of electrical signals exactly duplicating in time and amplitude, the sounds of the human heart, has become a very important tool in monitoring the physical condition of patients in extensive care wards. To calibrate and check out such a device, it is necessary to simulate, with accurate control,

and the 35-50 Hz multivibrator generates the frequency within each "heart sound" pulse. Circuit resistances are used to control pulse amplitude and a potentiometer is used to regulate output voltage level.

The phonocardiogram simulator can be used to check out telemetry and instrumentation systems



the timing and amplitude of heart activity signals. A phonocardiogram simulator accomplishes this with the instrument shown in the figure, producing the illustrated waveforms. The timing and amplitude of the waveforms can be adjusted to simulate all known ranges of human heart activity.

A one-Hz square-wave multivibrator generates the basic repetition rate of the signal waveform

for monitoring in medical centers and can also be used as an aid for training personnel to use the real system.

Source: John M. Keefer
Kennedy Space Center
(KSC-67-94)

Circle 17 on Reader's Service Card.

ELECTRONIC TEST SIMULATOR GENERATES PHYSIOLOGICAL WAVEFORMS

A physiological waveform simulator produces signals closely approximating those normally picked up by biosensors attached to the human body. Voltage and impedance levels of the waveforms can readily be interfaced with conventional

telemetry systems. The physiological functions which can be simulated include body temperature, respiration rate, blood pressure, and the axillary and sternal electrocardiograms.

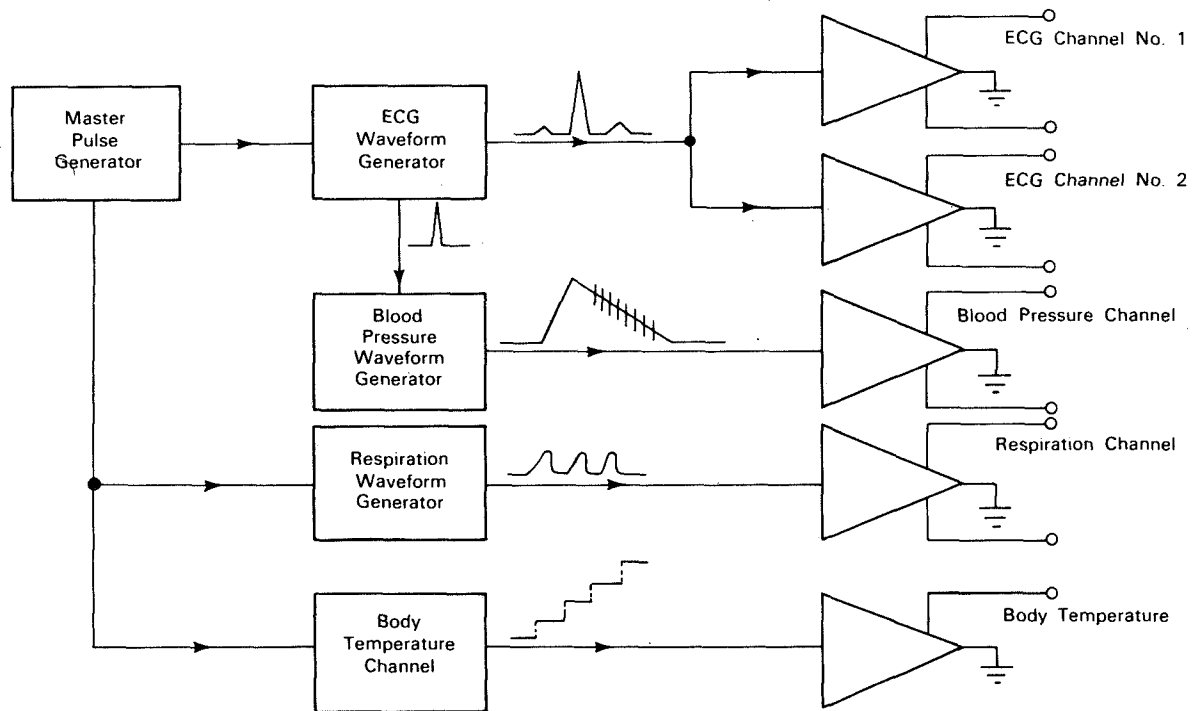
This simulator could be used effectively in hos-

pitals, medical research institutes, and medical schools for the propagation and study of typical physiological waveforms and for the checkout of biomedical instrumentation.

The electronic circuits include a master pulse generator that feeds the ECG channels a triangular pulse variable from 35 to 85 beats per minute. Monostable vibrators in the ECG channels produce fixed-duration square-wave pulses that are

vibrator. The repetition rate of this waveform is controlled by a three-position switch. After wave shaping by an R-C network, the waveforms are fed to a differential amplifier that controls the signal amplitude and processes the signal to a form compatible with the telemetry system being used. The output of the differential amplifier is used to simulate three human respiration rates.

The body temperature channel is a high-level,



applied to the differential amplifiers where the axillary and sternal electrocardiograms are formed.

An output from the ECG channels feeds the blood pressure channel to produce a composite signal that is applied to the differential amplifier, the output of which is manually adjustable. The resultant output signal is used to simulate the normal human blood pressure waveform.

For the respiration rate channel, the master pulse generator is an astable (free running) multi-

single-ended channel providing dc voltage levels corresponding to six simulated body temperatures—95°, 97°, 99°, 101°, 103°, and 105°F—manually selected by a switch. Simulation of body temperature by manually selecting a voltage analog rather than using a continuous staircase sweep effects a substantial reduction in circuit complexity.

Source: Stig Skeroot
Manned Spacecraft Center
(MSC-90094)

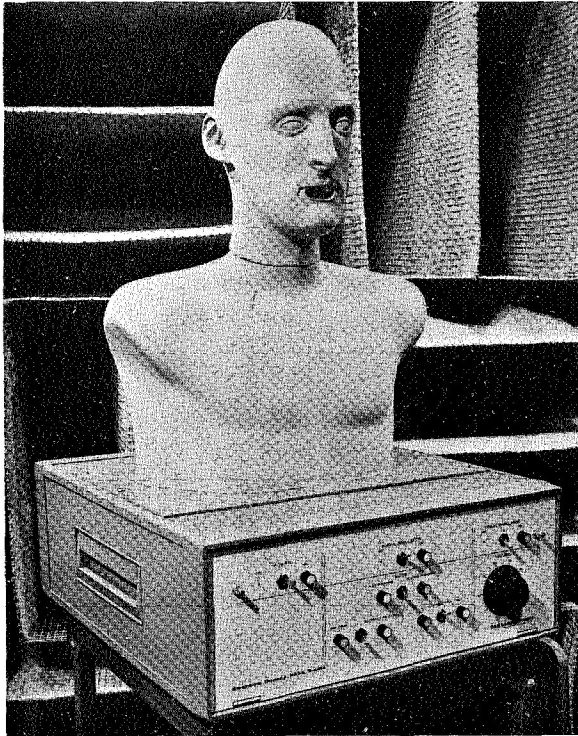
Circle 18 on Reader's Service Card.

ELECTRONIC DUMMY FOR ACOUSTICAL TESTING

The electronic dummy is designed and fabricated to aid in laboratory tests that are inde-

pendent of variations unique to human subjects. It should prove to be a valuable tool in under-

standing the biomedical aspects of acoustical theory.



The manikin shown in the figure represents the average male torso from the chest upward and includes an exact replica of the human head. As designed and fabricated, the head simulates natural flesh impedances and has artificial ears that measure sound pressures at the eardrum or the entrance to the ear canal. A unique hearing mode amplifier provides automatic and continuously variable loudness contour equalization. The artificial voice is fabricated from a modified, commercially available loudspeaker and an aluminum coupler that links the speaker to the oval-shaped mouth opening. The required response equalization is achieved electronically.

In the hearing response mode, the outputs of the ear canals are fed to hearing-mode amplifiers that simulate the average male hearing response as a function of sound pressure level at the eardrums.

Source: B. B. Bauer, A. J. Rosencheck, E. L. Torick, M. Stern, and A. L. DiMattia of CBS Laboratories under contract to Manned Spacecraft Center (MSC-90206, 1164, 1165, and 1166)

Circle 19 on Reader's Service Card.

ELECTRONIC SENSOR MEASURES SKIN TEMPERATURE

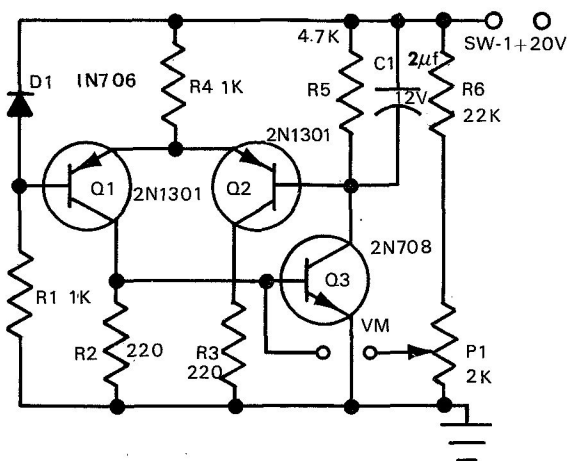


Figure 1A. Electrical Schematic

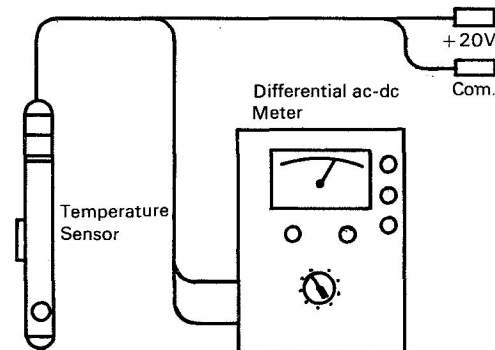


Figure 1B. Instrument Setup

The electronic temperature sensor has use in a wide variety of biomedical applications where surface temperatures ranging from 0° to 100°C must

be measured with high precision. The unit consists of a printed circuit with a transistor as the heat sensor, a magnet-operated reed switch, a

plastic head and a connector. The plastic head has a groove to lock the transistor in place so that pressure applied to the sensor will not bend the transistor leads. The unit is small and slender and can fit into or on small objects. It removes very little heat from the object under test and can be used to better advantage than a thermocouple, since most thermocouples depend on absorbing heat from the source.

Calibration is accomplished by adjusting potentiometer P1 to obtain a zero reading with the sensing head placed in contact with a 0° surface. The sensing head is then placed in contact with a surface having a known higher temperature, and

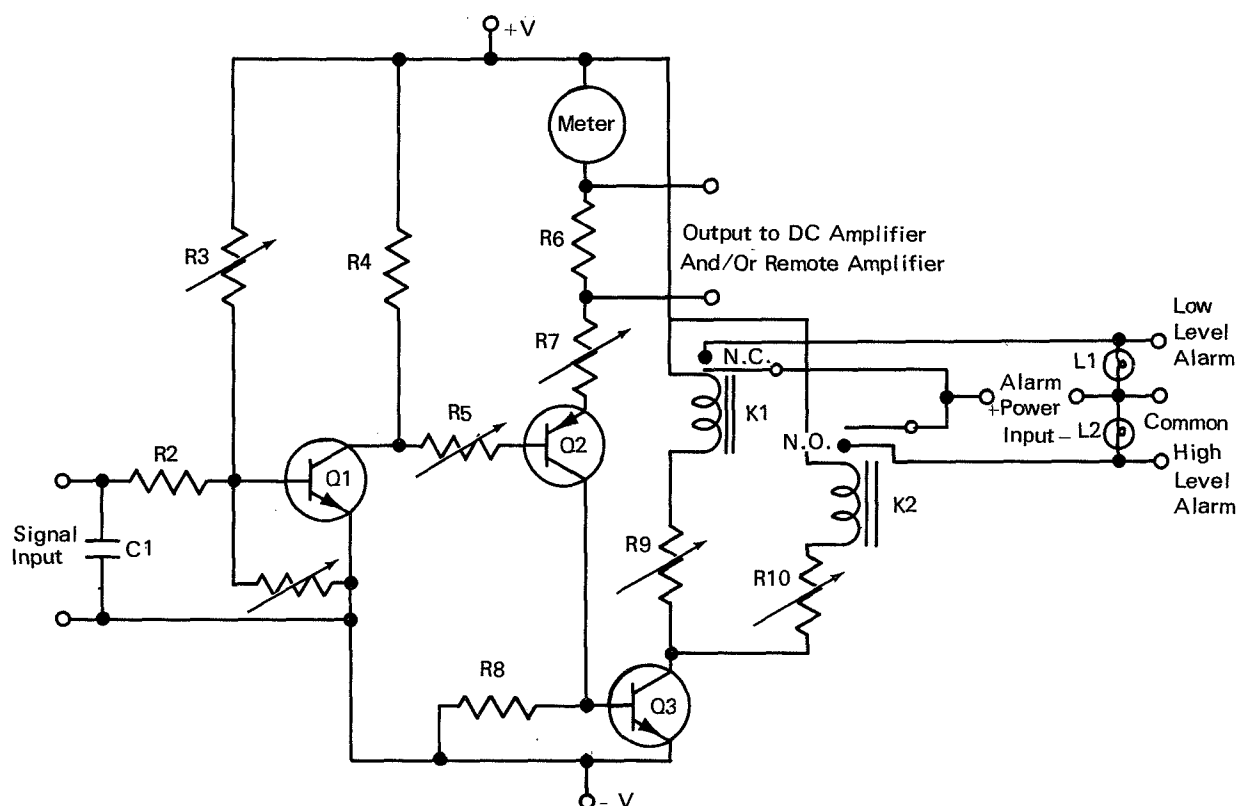
the millivolt reading is taken. The millivolt/temperature relationship is linear, so a conversion chart is easily constructed by drawing a straight line through the intercept data points. The reed switch makes possible the insertion and removal of the printed circuit from the tube without the necessity of connecting and disconnecting wire or mechanically installing and dismounting a switch.

Source: J. Craft of
Chrysler Corp.

under contract to
Marshall Space Flight Center
(MFS-14458)

No further documentation is available.

DC INSTRUMENT MEASURES PHYSIOLOGICAL ELECTRICAL POTENTIALS



The instrument shown schematically in the figure can measure current and voltage derived from physiological parameters. It consists of a simple dc microammeter, a dc amplifier, and two relays for activating indicating lights and remote control devices.

Since the first two transistors (common emitter and common collector stages) yield a very high gain, the input impedance can be made sufficiently high to prevent loading. Measurement of physiological parameters which vary about zero is obtained by adjusting the zero for midscale

on the meter. This is accomplished by biasing the first stage at approximately 50% of saturation and allowing the signal to add or subtract (depending on signal polarity) from the no-signal current.

The solid-state driven relay limits in parallel with the meter eliminate the need for contact-type relay meters, which are extremely unreliable due to contact wear. Photocell type relay meters are much more complex than the meter and alarm circuits and are more than double in cost. The

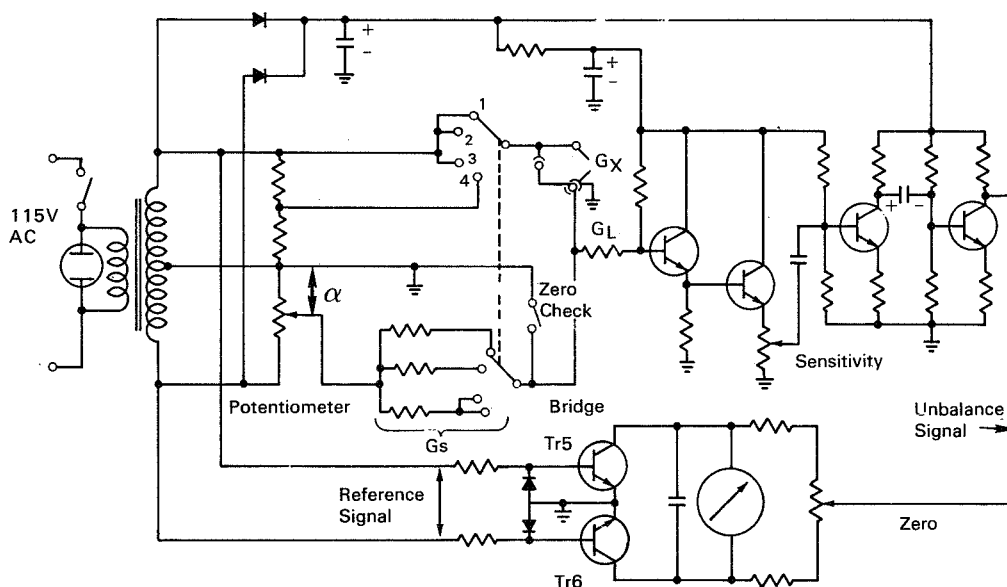
cost of this instrument is many times less than others which provide these functional capabilities. In addition, the simplicity of the circuit permits a more compact, lightweight package which lends itself to portability.

Source: C. Solomon and D. Payne of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-12833)

Circle 20 on Reader's Service Card.

Section 4. Electronic Test and Measurement Equipment for Earth Resources Applications

SENSITIVE BRIDGE CIRCUIT MEASURES CONDUCTANCE OF ELECTROLYTE SOLUTIONS



An instrument with a sensitive bridge circuit has been developed to measure the conductance of electrolyte solutions. The compact bridge circuit achieves an accuracy of approximately 0.2% with the use of a phase-sensitive detector that produces a linear deflection of the null indicator relative to the measured conductance. Four conductance measurement ranges are available from 1 μ mho to 1 mmho.

The unbalanced signal voltage applied to the bridge is amplified, substantially free of phase shift, by the transistor amplifier network and fed to the phase sensitive detector which acts as a reference voltage operated switch to produce a square-wave function reference signal. The unbalance signal is presented as a dc component of the product, and indicated on the microammeter. The meter deflection is proportional to the product

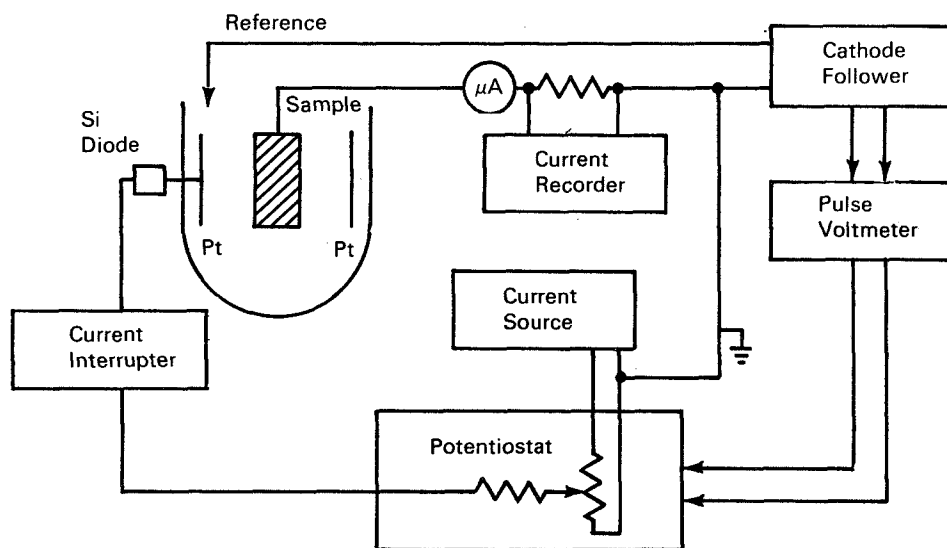
of the absolute value of the unbalanced voltages.

The instrument can also be used in water pollution studies to determine the increase in water conductivity caused by contaminants.

Source: K. Schmidt
Argonne National Laboratory
(ARG-147)

Circle 21 on Reader's Service Card.

INSTRUMENTATION FOR POTENTIOSTATIC CORROSION STUDIES WITH DISTILLED WATER



Corrosion can be studied in the environment of distilled water with an instrument that measures the potential of the corroding specimen immediately after interruption of the polarizing current. The process is essentially continuous, with interruption of the current for 6 msec of every 100pp-msec period. A method for control of the polarizing current at a preset level permits compensation for IR drops when potentiostatic control is used in high-resistance systems.

A simple potentiostatic circuit is connected to a pulse voltmeter through an adjustable-bias voltage supply. The function of the voltmeter is to determine the value of the fluctuation voltage of interest regardless of the value of the solution

IR drop and to provide a nonpulsating output voltage.

The temperature of the test cell is kept constant by a 70°C water bath and the corrosion medium is degassed, distilled water. A hollow platinum cylinder, fitting closely inside the closed cell, serves as a current carrying electrode. The sample is a solid aluminum cylinder having its ends blanked with TFE fluorocarbon insulators for maintenance of equal current density at all exposed areas.

Source: C. A. Youngdahl and R. E. Loess
Argonne National Laboratory
(ARG-10409)

Circle 22 on Reader's Service Card.

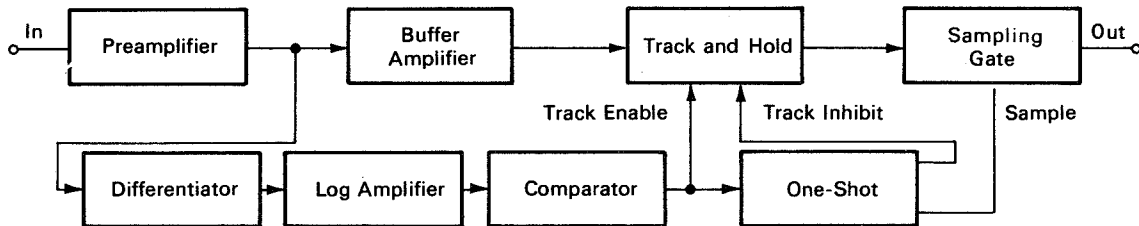
CONDITIONING OF PULSES FROM AEROSOL-PARTICLE DETECTORS

A new method of conditioning electrical pulses, generated by aerosol-particle detectors, enables commercial nuclear instrumentation to be used for

the particle analysis. The detectors of aerosol particles generate electrical pulses, Gaussian or half-sinusoidal in shape, that are related to the size

and distribution of the particles. The characteristics of the aerosol pulse require a pulse-conditioner that must interface with the nuclear-energy pulse height analyzer. Such a conditioner

over a wide dynamic range. The complete system has immediate application in air pollution studies where particulate size and distribution must be determined.

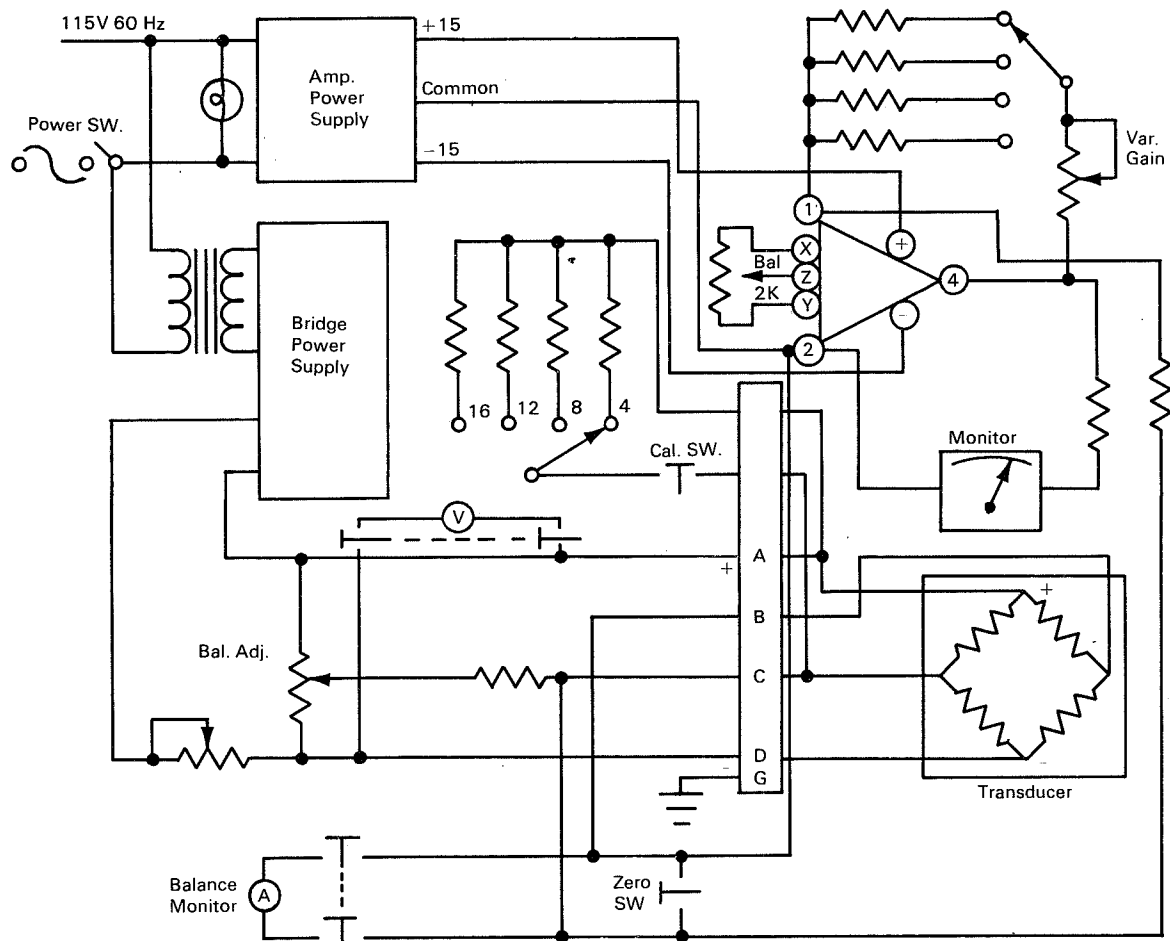


has been developed and made compatible with two commercial pulse-height analyzers. The pulse conditioner shapes the pulses in the proper form while processing the amplitude information linearly and

Source: C. T. Martin and J. E. Bowie
Electronics Research Center
(ERC-10250)

Circle 23 on Reader's Service Card.

PORTABLE INSTRUMENT MONITORS TRANSDUCER PERFORMANCE



A portable monitor for strain gage type transducers which uses modular plug-in dc operational amplifiers is shown in the figure. It has the attractive feature of plug-in calibration cards which can be changed to calibrate a strain gage bridge of any resistance value. This instrument can be used in any system containing a strain gage bridge and where continuous monitoring is required. Typical uses include: gas analysis for air pollution studies, critical data points in structures tests, and remote pressure readings associated with hazardous tests.

The unit is a portable package consisting of a bridge power supply, amplifier power supply, bridge balance, shunt resistance calibrator, operational amplifier, and scale panel meter. The moni-

tor is used in conjunction with strain-gage type transducers to provide continuous transducer output indication, under steady state or gradually changing conditions. A chronic problem—capacitance pickup—is eliminated in this unit by the use of shielding and an encapsulated technique in the operational dc amplifiers. The dc operational amplifiers have excellent long term stability and temperature characteristics.

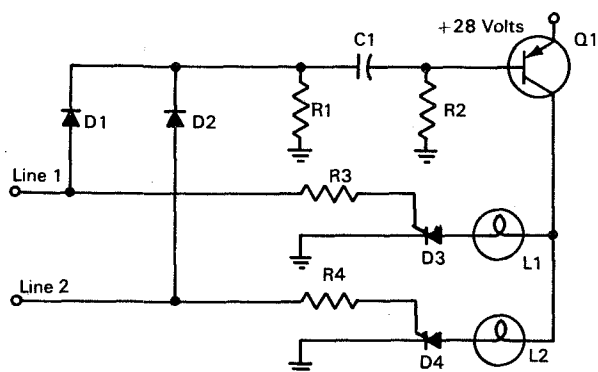
Source: Robert R. Walker of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15016)

No further documentation is available.

Section 5. Electronic Instrumentation for Test and Checkout of Complex Systems

ELECTRONIC TEST DEVICE SENSES MALFUNCTIONS IN TEST INSTRUMENTATION

The electronic test device shown in the figure is used in the test and checkout of complex systems to differentiate between malfunctions occurring in the system undergoing test and malfunctions within the test instrumentation itself. The



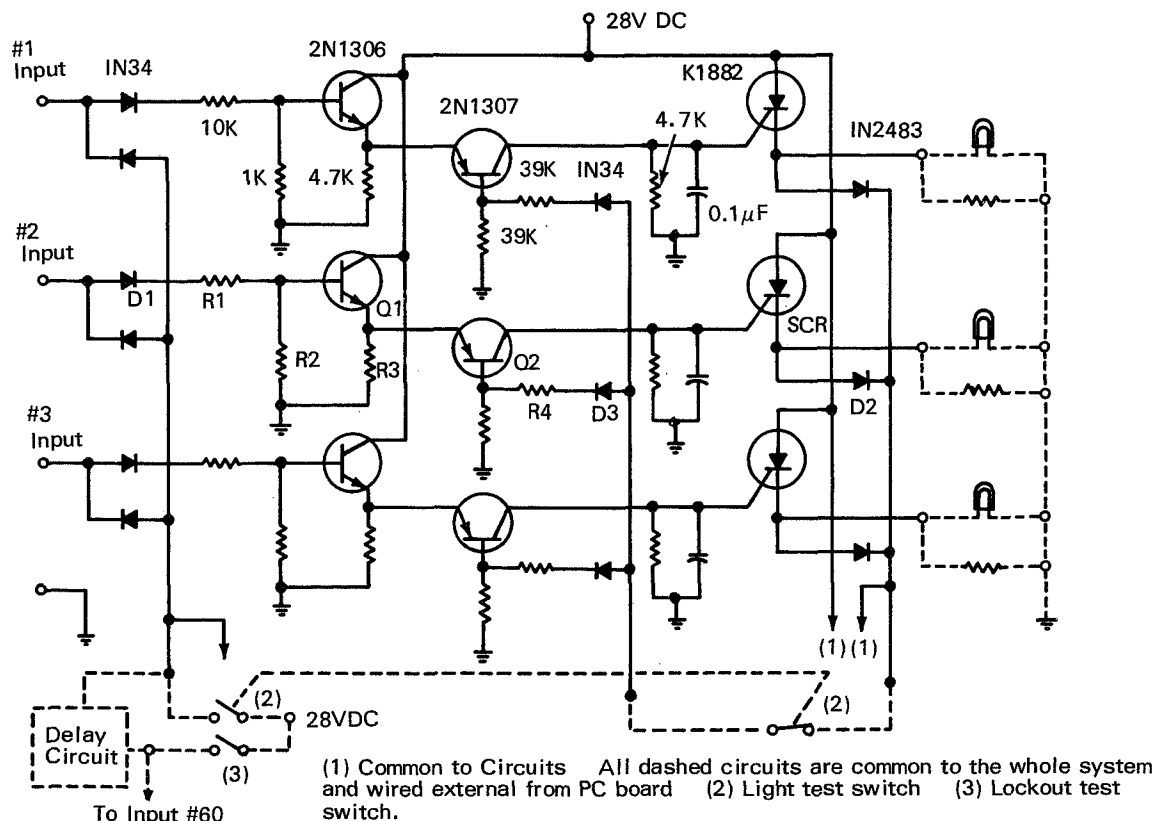
origin of the malfunction is quickly isolated. Electronic circuits in the monitor use transistors to commutate silicon controlled rectifiers by removing the drive voltage; display circuits are then used to monitor multiple discrete lines.

All monitored lines are connected to the "OR" circuit composed of D1, D2 and R1. This circuit detects the presence of pulses on the lines; a composite pulse is passed to the differentiation elements, C1 and R2, which form a narrow positive pulse. The pulse turns off the commutation transistor, Q1, that commutates the silicon controlled rectifiers D3 and D4, causing them to reset. The leading edge of the incoming pulses is used to reset the rectifiers and the remaining period of the pulse fires the rectifiers on the lines carrying pulses. The conducting rectifiers enable the appropriate lamp to light which indicates the origin of the malfunction. At least twenty lines can be connected to the monitoring circuit, provided that no more than twenty lamps are lighted at the same time.

Source: William M. Miller, Jr., of
The Boeing Company
under contract to
Kennedy Space Center
(KSC-10209)

Circle 24 on Reader's Service Card.

SOLID STATE ANNUNCIATOR DISPLAYS MALFUNCTIONS IN COMPLEX ELECTRONIC SYSTEMS



The solid state annunciator monitors up to 70 input signals for a dc voltage change from 0 to 28 V dc. Changes in the dc voltage indicate the location of the malfunction which must be corrected. Three typical channels are shown in the figure. With all inputs at zero potential and the unit in the reset mode, a 28 V dc signal is applied to the number 2 input. Q1 is turned on to establish a threshold against noise, which could otherwise cause a false response. The output from Q1 is applied to the emitter of Q2 which will conduct as long as it is not biased for cutoff. The collector output of Q2 is applied to the gate of the SCR causing it to conduct. The 28 V dc at the cathode of the SCR lights the lamp to indicate the channel associated with the first malfunctioning test component. The 28 V dc is also applied to a bus that biases the bases of the

Q2 transistors, through the R4 resistors, to lock out all other SCR rectifiers.

A light-test circuit checks for proper operation of all channels by interrupting the feedback from the SCR cathodes to the Q2 bases and simultaneously applying a 28 V dc to all inputs. A lock-out test circuit applies a signal to only 1 input and after a 10 to 20 sec delay, to all other inputs. If the system is functioning properly only the lamp that is associated with the first energized input will light.

Source: H. P. Hofer of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-1258)

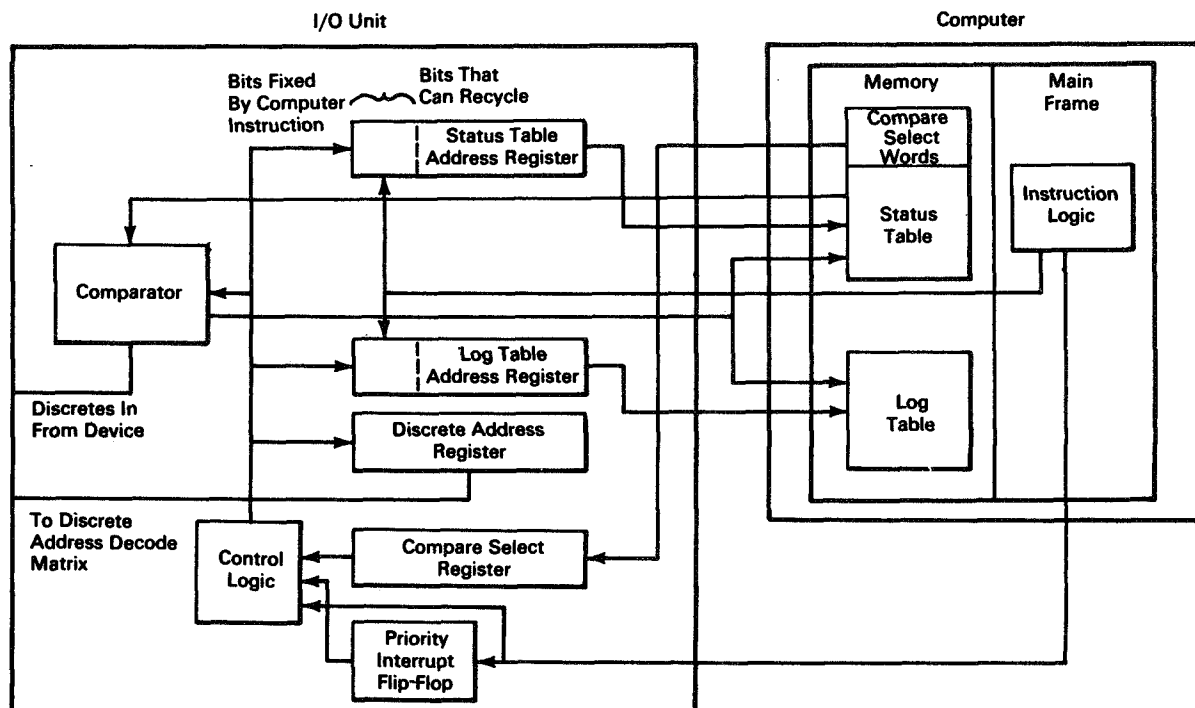
No further documentation is available.

ELECTRONIC TEST AND CHECKOUT SYSTEM MONITORS DISCRETE COMPUTER INPUTS

An automated electronic checkout system can monitor several thousand discrete input lines to a digital computer. The monitoring system has the capability to log sufficient information about the changes in the input signals so that their history can be reconstructed. In the event of a discrete input change, the test and checkout system can interrupt the program that the computer main frame is performing in order to take action to ser-

change in the selected discrete lines, a Priority Interrupt is actuated to cause the computer to interrupt the program and begin a predesignated program whenever a noncompare is found on selected discrete lines.

The computer main frame and memory are available for other functions. Compare, address and control functions are performed in logic blocks within the I/O unit. Since the discrete data rate



vice the device being checked. The monitoring and logging do not usurp the computer processing function or memory accesses.

The discrete lines are scanned a sufficient number of times to update the data. On every scan the condition of each line is compared with the data already in a Status Table from a previous scan. When a difference is detected, the Status Table is updated. At the same time, the new status, time of compare, and discrete addresses are stored in a Log Table in the computer memory. The Input/Output Unit (I/O), by virtue of bits stored in a Compare Select Register, senses discrete signals which are to be monitored.

When special action is required as a result of a

of change is slow, the scanning rate need not be at the maximum memory access rate. The availability of accesses for each I/O is determined on a memory access priority basis. The Log Table length is optionally determined by the computer instruction. When the selected table length is half-filled or filled, the computer can be interrupted and caused to jump to a preselected routine.

Source: J. J. Burns of
Radio Corporation of America
under contract to
Marshall Space Flight Center
(MFS-1021)

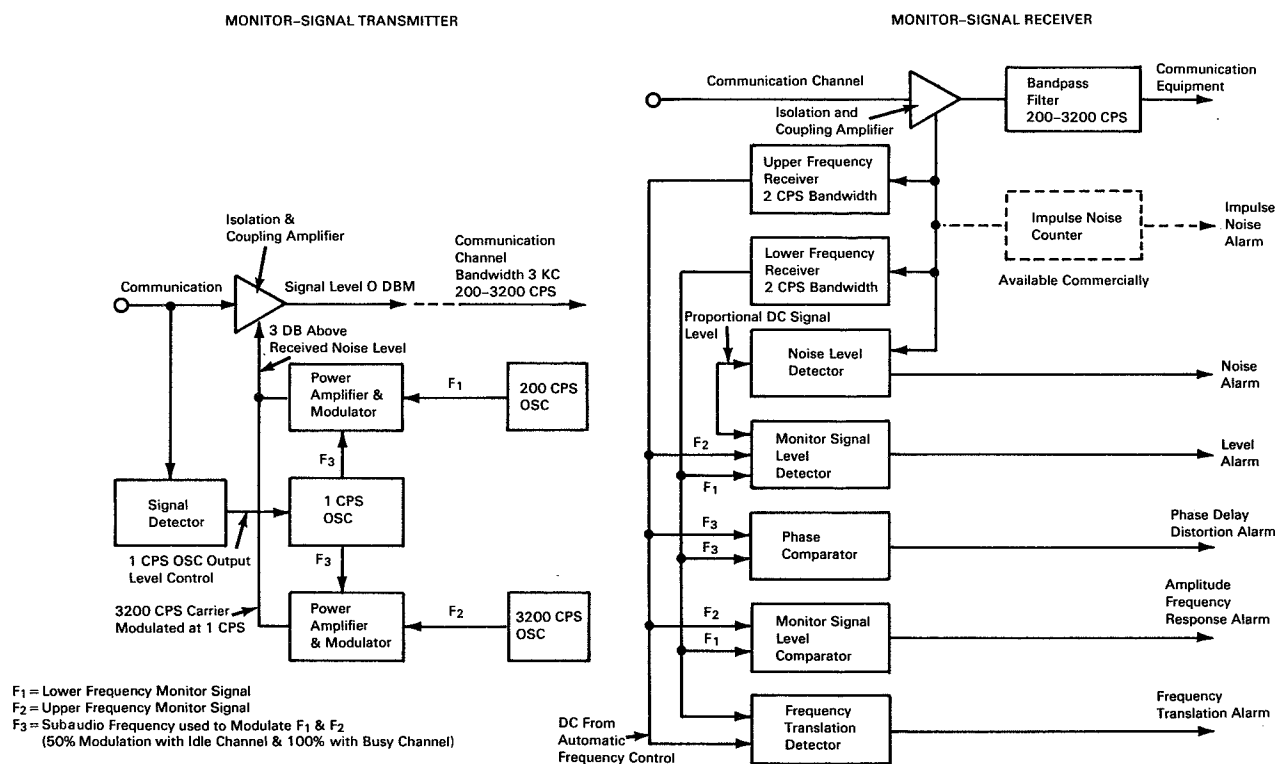
No further documentation is available.

TEST MONITOR ASSURES AVAILABILITY AND QUALITY OF COMMUNICATION CHANNELS

The electronic monitoring system shown in the block diagram continuously monitors a communication channel for proper circuit parameters and energizes an alarm if these parameters do not fall within allowable limits. The system assures the availability and quality of a communication channel, whether in use or idle. It determines when an idle channel has been interrupted or has deteriorated below usable standards, and monitors the channel quality during circuit use. Unlike other

and the other at the high frequency end. The monitor-signal receiver detects the transmitted monitor signal and measures its power level, phase delay, frequency amplitude response, and degree of modulation. An alarm sounds if any of these measurements do not fall within normal limits.

The channel quality monitor can be used in voice and high-speed data channels to assure circuit quality and channel availability. It is especially useful in high priority voice channels which do not



quality monitoring devices that are commercially available and in general use for telegraph and low-speed digital circuits, this system can monitor channels carrying voice or other signals that contain many random frequencies and all the critical parameters of voice and high-speed data circuits.

A monitor signal transmitter is at the transmitting end of the channel and a monitor-signal receiver at the opposite end; the monitor signal transmitter generates two amplitude-modulated signals that are within the communications channel frequency band, one at the low frequency end

carry traffic most of the time, but which must be operational and available immediately. In data circuits, it could signal substandard channel conditions that would ordinarily result in lost time and data.

Source: George P. Smith of
The RCA Service Co.
under contract to
Kennedy Space Center
(KSC-66-38)

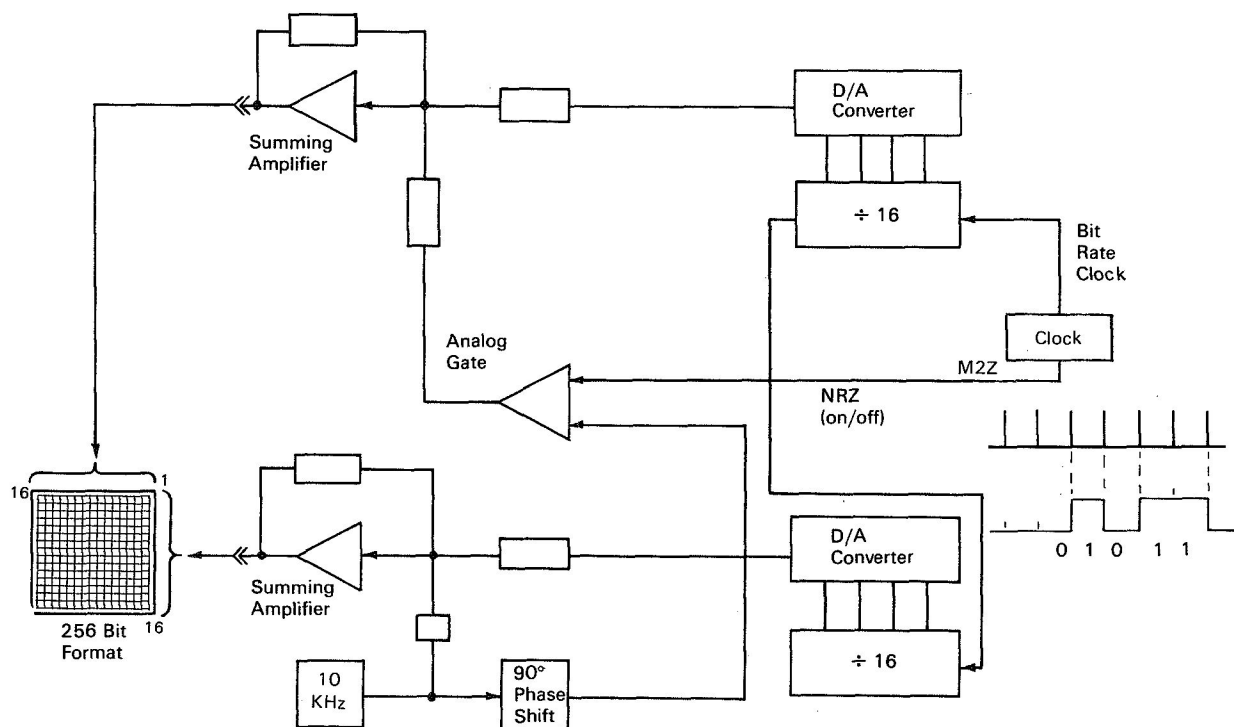
Circle 25 on Reader's Service Card.

NUMERICAL DATA FRAME READOUT SYSTEM USED IN TESTING TELEMETRY SYSTEMS

The electronic system shown in the block diagram, used for the test and checkout of complex digital telemetry systems, has a display system that directly reads out the test data in a numerical format. The display is in a 256-bit rectangular data format with 16 rows and 16 columns assigned to each frame. The system lends itself to expansion or contraction to suit any desired format.

In operation, the system forms an oscilloscope raster display generated by bit-to-bit and line-to-

the sine wave, thus generating a numerical "1" equal in height to the peak-to-peak amplitude of the sine wave. In the presence of a "0" data bit, both vertical and horizontal inputs receive sine wave components, and the 90° displacement in phase angle will cause a numerical "0" to appear. Ten cycles of beam deflection are again encountered for each bit presented, providing ample retrace for use with low persistence or low response time oscilloscopes. Synchronization of readout se-



line electron beam deflection from staircase sweep signals, where each beam location is coherent with an incoming data bit. Coherence is readily established by clocking the binary counters with the bit rate clock. At each beam location, either a "1" or "0" is formed by generation of Lissajous figures, where the particular pattern is determined by the state of a data bit at the NRZ input. In the case of a "1" (voltage level in NRZ pattern), the vertical input receives a 10 kHz sine wave component, while the 90° sine wave component is blanked at the horizontal input. If the data bit interval is 1 millisecond, the electron beam is deflected in a vertical direction over 10 cycles of

quence with incoming data is accomplished by clearing the binary counters at the beginning of the readout sequence.

This display system can be used to show bit dropouts at a memory output or to locate a failure or malfunction in a particular portion of a system. Telemetry system operation can also be checked for errors caused by noise or weak signals in the transmission link, thus determining bit error rates.

Source: John R. Cressey and Charles E. Cote
Goddard Space Flight Center
(GSC-90551)

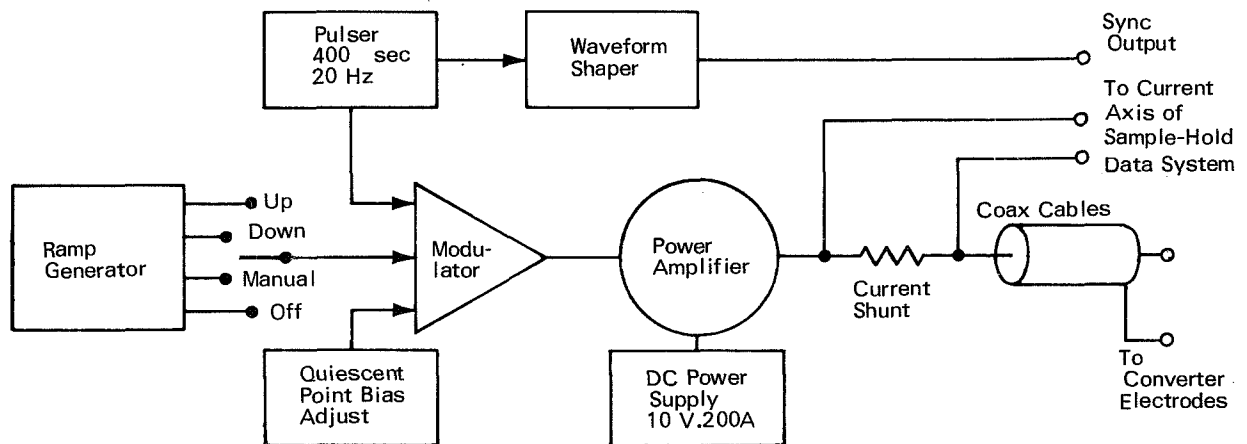
Circle 26 on Reader's Service Card.

TEST INSTRUMENTATION RECORDS CURRENT-VOLTAGE CHARACTERISTICS OF THERMIONIC ENERGY CONVERTERS

This innovation provides an accurate and efficient means of obtaining volt-ampere curves of thermionic converters and similar electronic devices. The new method and apparatus consist of a heavy current generator that pulses a thermionic converter over a small duty cycle, and means to sample and hold the data obtained over a small fraction of the pulse period; the data are displayed on an oscilloscope or a recorder.

The system operates by applying a series of short duration, high current electrical pulses to a thermionic converter and then periodically sampling

Major features of this novel method are the pulsing of a converter at a duty cycle of 0.8%, synchronous sampling of the data, and provision for a sample-hold capability. Also, a substantial reduction of the heat delivered to the collector of the converter enables the measurements where neither an ordinary steady-state method nor a 60 hertz dynamic-sweep method could be used. The use of this instrumentation is recommended for testing electronic devices that are sensitive to temperature changes resulting from current flow through them.



the resulting voltages and currents. The test system provides both technique and instrumentation for determining voltage and current characteristics of temperature-sensitive thermionic converters without biasing the test data through instrumentation interaction with the device undergoing testing. The system can be used in widespread industrial applications where very accurate current-voltage profiles are required.

Source: Katsunori Shimada and Paul L. Cassell of Caltech/JPL under contract to NASA Pasadena Office (NPO-10675)

Circle 27 on Reader's Service Card.

FACILITY POWER MONITORING SYSTEM RECORDS TRANSIENT DISTURBANCES

A power monitoring system allows detection of facility power transients as short as 0.0002 second, and uses only a very small amount of recording paper. The exact voltage wave shape is recorded permanently on a 24-hour basis. An attractive feature of the system is the use of recorder

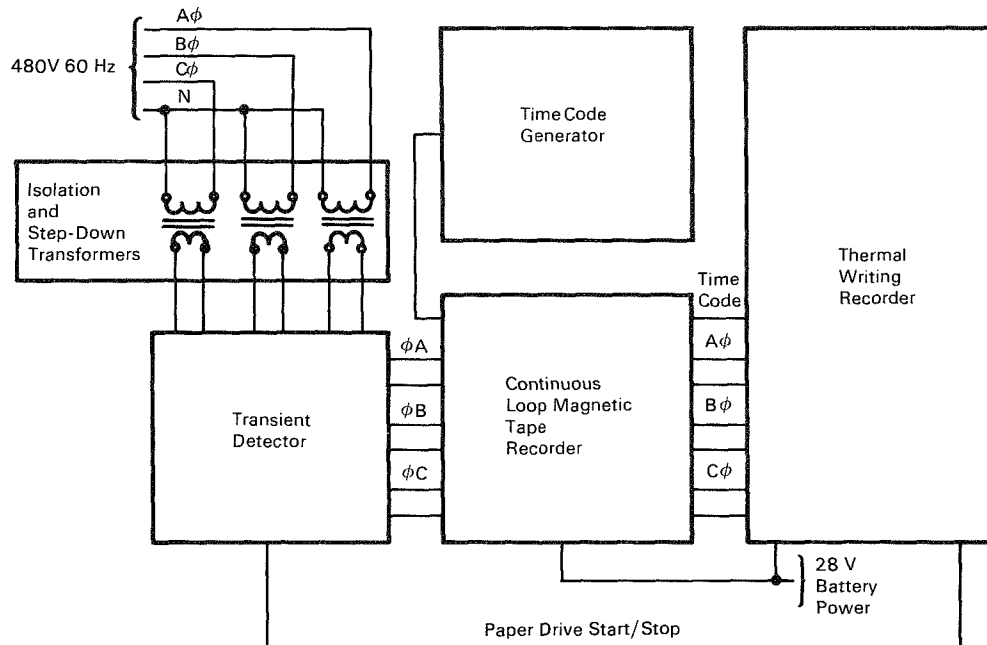
paper only when a transient occurs. Previous methods could not record the voltage wave shape on a 24-hour basis without using thousands of feet of paper per day.

Any industry that relies on transient-free line voltage for supply to sensitive electronic systems,

particularly digital computers, would have use for this system.

In operation, a continuous loop magnetic tape records the three phases of line voltage, plus a binary time code. As the tape loop arrives back at the capstan area, all of the recorded data pass the

period after the entire loop of magnetic tape has passed the reproduce heads, the thermal writing recorder paper drive stops. The entire recording system is powered by a 28 V battery system so that the line voltage transients will not cause invalid data to be recorded.



reproduce heads prior to re-recording new data. A transient detector, connected directly to the AC line, senses all line voltage transients. The detector commands the paper drive to start and allows the thermal writing recorder to run and record the reproduced data from the magnetic tape. A short

Source: Paul Wasserman and Clifford K. Knox of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-16050)

No further documentation is available.

Section 6. Electronic Test Methods Ensure Quality Control and Reliability Assurance

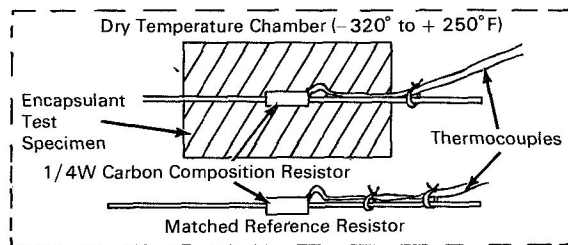
QUICK AND RELIABLE TECHNIQUE FOR EVALUATING PHYSICAL STRESSES ON ELECTRONIC COMPONENTS

The dissimilar thermal expansions of electronic components and encapsulant materials cause high stress loads on the components which result in damage and loss of component reliability. A measurement technique has been developed to aid in selecting an optimum encapsulant process to ensure

electronic module reliability for extreme temperature environments. The basic relationship between encapsulation stress and temperature has been determined by comparing the difference in electrical resistance between an encapsulated resistor and a matched resistor, over the temperature range

of interest, when all major variables are compensated or nulled.

Throughout the test program the resistors are thoroughly dried and kept in a desiccant-filled bag. All resistors receive an initial 48-hour bake at 250°F with additional bakes before test runs.



Tests show that resistor temperature coefficients are sufficiently identified by measuring resistance at -320°F (liquid nitrogen), room temperature, and at +250°F. Resistors displaying a resistance change (from room temperature) within ± 1 ohm are grouped together as being matched for temperature coefficient.

All but one resistor in each matched set are used to evaluate encapsulant test materials. Resistance

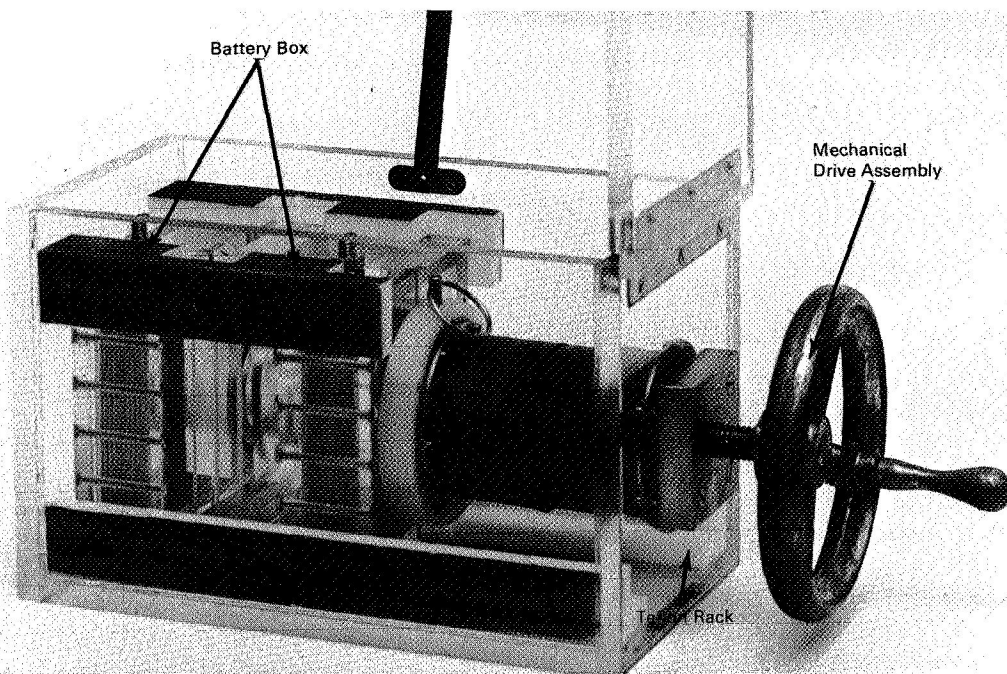
measurements are made on both the encapsulated and unencapsulated resistors in 50°F increments for the range of temperatures of -320° to +250°F. Care is taken to ensure that the reference resistor and the test samples are at the same temperature for each measurement.

A plot of temperature vs. the difference in resistance of the encapsulated resistor and the reference resistor reveals the stress induced from the encapsulants' temperature coefficient of expansion. Since the loads imposed on the resistor body are nonuniform, actual values of stress are not determined (or needed). This test technique quickly and inexpensively determines the relative stress levels on components to aid in the evaluation of encapsulants as well as the protective qualities of sleeves and thin coatings.

Source: K. A. Moore of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-14573)

Circle 28 on Reader's Service Card.

INTERNAL RESISTANT MEASUREMENT OF BATTERY SEPARATOR MATERIALS AID IN QUALITY ASSURANCE



Accurate measurements of the internal resistance of battery separator materials can be made with the test device shown in the figure. The resistance of the separator between the positive and negative plates of a liquid electrolyte battery has been the object of considerable developmental effort because it is an important parameter in the evaluation of new separators.

The test device consists of a water-tight plexiglass box that encases a track-mounted electrode assembly. Two battery boxes are mounted on L-shaped Teflon tracks with an additional assembly that contains reference electrodes and seals the separator to be tested between them. The battery boxes are designed to provide 12 amp-hr of current for the resistance measurements.

The test circuit includes a variable power source which must be turned on initially so that the cadmium electrode stacks are partially charged. If

increased accuracy is desired in measuring the current, a combination of a shunt and a voltmeter can be introduced into the circuit. A potentiometer is used to measure the voltage between two reference electrodes whose current path is formed by capillary tubes which extend to either side of the separator.

An important feature of the test device is the mechanical drive of the electrode battery box which enables the interchange of samples without loss of electrolyte. The use of battery boxes mounted on tracks also enables large capacity electrode stacks to be employed so that a wide range of test currents are available.

Source: Stephen A. Kissin, Frank E. Briden and

Thomas J. Hennigan

Goddard Space Flight Center

(GSC-10666)

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UNIVERSAL MOUNTING BOARD FOR QUALITY ASSURANCE TESTS OF ELECTRONIC COMPONENTS

An integrated circuit (IC) testing board, consisting of a glass epoxy substrate and component mounting fixtures, provides a test mount that is compatible with most of the presently used integrated circuit connectors. Use of the mounting board simplifies the quality assurance test functions of reverse bias, burn-in and life-test of transistors and linear and digital IC's. These functions are needed for qualification testing of electronic devices, used in commercial and aerospace applications where high reliability is required.

The parts mounting board is built from glass epoxy, utilizing standard printed circuit card fabrication techniques. Each board contains 24 positions, with 16 pins per position. Test parts and control circuit components are located on the opposite side of the board from the solder pads. Four test points per device are brought outside the chamber for monitoring purposes; cross-over lines and input signal lines are floated, allowing several different types of devices to be tested on

the same board. All pads and signal lines are identified for simplicity of design test circuitry and ease of assembly. The operational temperature range, from -65° to 150°C , is achieved without the use of a special temperature chamber.

Novel features of this mounting board include: (1) low interlead capacitance allows dynamic life testing and burn-in of linear devices in the active region; (2) several device types can be tested on the same board concurrently; (3) no manual soldering is required; (4) control circuit is easy to assemble; and (5) low cost due to the fact that only one board is required instead of a board for each type of device.

Source: Robert E. McNeill of

The Boeing Company

under contract to

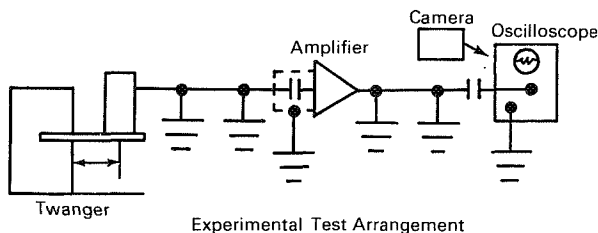
Marshall Space Flight Center

(MFS-15100)

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METHOD OF DETECTING LOOSE PARTICLES IN SEALED RELAYS INCREASES RELIABILITY

The method provides a means of identifying and displaying impacts of particles in a sealed relay. These particles can cause failure if they were to lodge in the mechanical working portions of the relay.



The test setup (see fig.) consists of a cantilever beam rigidly fastened at one end, with provisions for mounting a test specimen and an accelerometer at the free end. A stop is provided to limit the displacement of the free end so that the initial acceleration does not damage the component. The output of the accelerometer, when viewed on an oscilloscope, shows the damped waveform of the beam. High amplitude components (spikes) at particular time periods on the waveform represent

the impact of the loose particle on the relay case. Each cycle of motion contains two spikes as the particle impacts the upper and lower surface. As the vibration amplitude decreases, the small particle does not impact with sufficient force to be sensed by the accelerometer. The oscilloscope display of the filtered output signal provides a single trace of the entire sequence of damped wave output which can be correlated with the mass of the loose particle being detected, thus giving a quantitative measurement.

The fixture and detecting and recording system can be used to perform and document any kind of "rattle test". In particular, if the item being tested is fragile, this fixture provides a means of controlling the acceleration force applied.

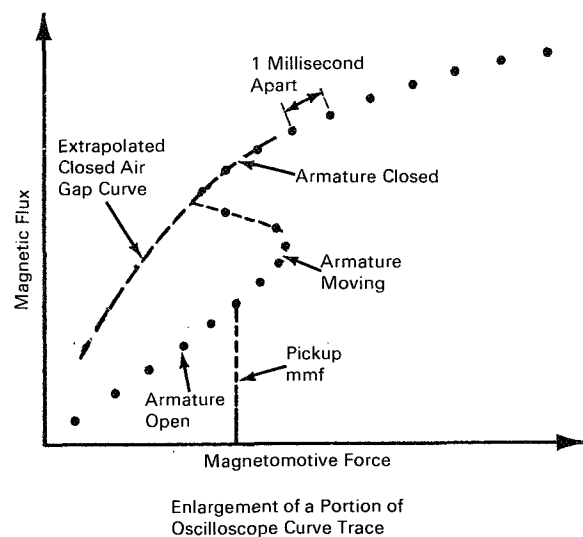
Source: Lyle Skjei, Al Cockle and
Kermit Andreason of
The Bendix Corp.
under contract to
Manned Spacecraft Center
(MSC-13070)

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TECHNIQUE FOR CALCULATING THE ARMATURE MOTION OF A HERMETICALLY SEALED RELAY

A technique to determine the amount of mechanical wear in the actuator, spring overtravel, and contact system of a relay has been developed for applications where periodic maintenance is performed. This procedure requires that each unit, when it is first installed, be evaluated and a photographic record made of its energy cycle curve and other transient data so that at inspection time a comparison can be made of the two records. From these records, information is obtained to estimate or calculate the amount of change that has occurred.

Basically, the technique consists of measuring the change in air gap length from the energy cycle curve which is displayed on an oscilloscope (see fig.). If the Z-axis of the oscilloscope is intensity modulated with a known fixed frequency signal, a plot of armature position as a function of time



can be obtained. An analytic expression for the air gap length derived in terms of the measured parameters determined from the energy cycle curve enables an equivalent magnetic circuit of the relay to be synthesized. The properties of the equivalent circuit define the relay operational characteristics. Any physical change in the relay can be deter-

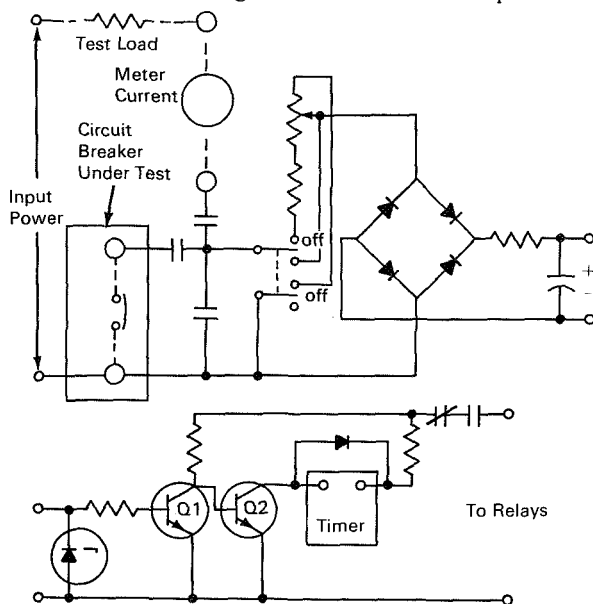
mined by a simple comparison with the original circuit.

Source: Oklahoma State University
under contract to
Marshall Space Flight Center
(MFS-14543)

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TESTER CHECKS OPERATIONAL PERFORMANCE OF CIRCUIT BREAKERS

The circuit breaker tester shown in the schematic has been designed to measure the triptime of



circuit breakers in accordance with the manufacturer's specifications. The tester can also subject

the breaker, with its lock-out device installed, to a specified current and operational lifetime.

The circuit breaker tester contains an elaborate current limiter in the event of testing a relay which could have a short circuit. A time-delay relay is provided with timing ranges applicable to the tripping time of the breakers undergoing test. The function of the relay is to remove power from the circuit breaker if it does not trip prior to the maximum allowable test time. In addition, currents, voltages, and operational time can be monitored for each relay.

Another application of the tester would be its use as a current limiter or overload-current warning device. The components of the test circuit have been selected for minimum cost and the capability of being microminiaturized.

Source: Charles Cole of
General Electric Co.
under contract to
NASA Headquarters
(HQN-10340)

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